

AD-A094 363

NATHAN (ROBERT R) ASSOCIATES INC WASHINGTON D C  
PROJECTIONS OF DEMAND FOR WATERBORNE TRANSPORTATION, OHIO RIVER--ETC(U)  
DEC 80

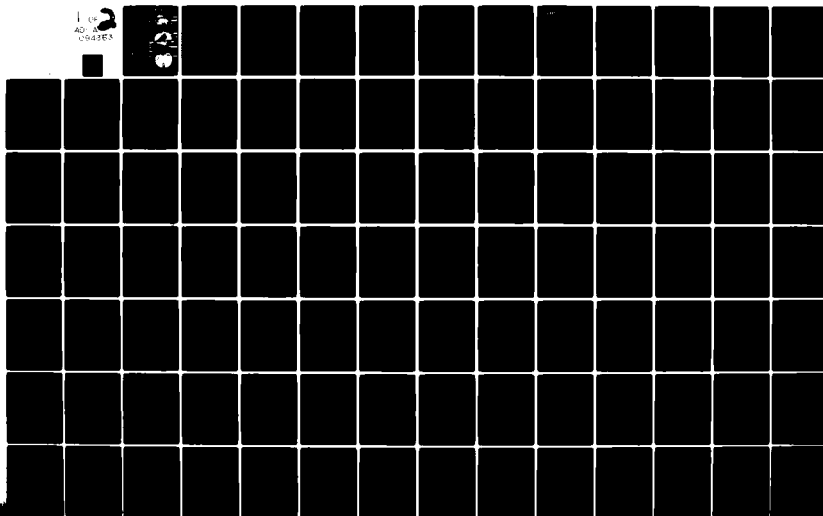
DACW69-78-C-0136

F/G 5/3

NL

UNCLASSIFIED

1 0  
AD  
0043EX



AD A094363

Projections Of Demand  
For Waterborne  
Transportation

Ohio River Basin  
1980 - 2040

Volume 7  
Grains

DDC FILE COPY

DTIC

1931

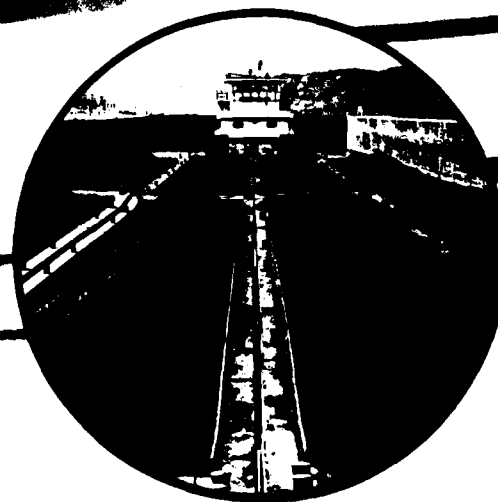
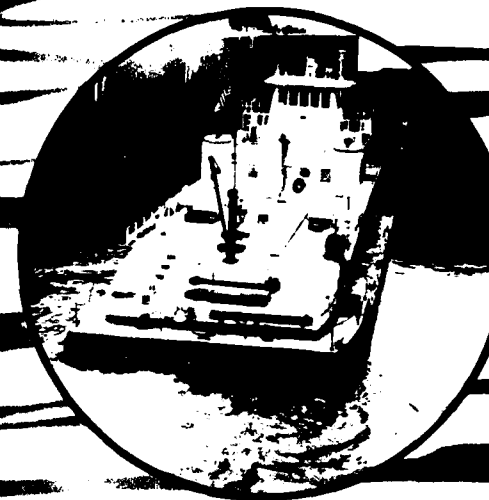
U. S. Army Corps of Engineers  
Ohio River Division  
Cincinnati, Ohio

DISTRIBUTION STATEMENT A

Approved for release;  
Distribution unlimited

LEVEL III 35

(12)



SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DD FORM 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

(Continued from #20)

The three study projections, in conjunction with other analytical tools and system information, will be used to evaluate specific waterway improvements to meet short and long-term navigation needs. The output from these studies will serve as input to Corps' Inland Navigation Simulation Models to help analyze the performance and opportunities for improvement of the Ohio River Basin Navigation System. These data will be used in current studies relating to improvement of Gallipolis Locks, the Monongahela River, the Upper Ohio River, the Kanawha River, the Lower Ohio River, the Cumberland River and the Tennessee River, as well as other improvements.

This document is volume 7 of the 17 volume report shown below.

The study included a Commodity Resource Inventory, a Modal Split Analysis and a Market Demand Analysis. The work included investigation and analyses of the production, transportation and demand characteristics of each of the major commodities transported on the Ohio River and its tributaries. For each of 15 commodity groups, the demand for waterway transportation into, out of and within the Ohio River Basin was projected through the year 2040. A detailed study analysis and discussion for each commodity group is presented in 15 individually bound reports, supplemented by a methodology report. A study summary aggregates the commodity group totals for each of the several projections periods and lists the total waterborne commerce for each of the 72 operational locks and dams in the Ohio River Basin. The study results are presented in the following 17 documents:

| <u>Volume</u> | <u>Subject Title</u>  |
|---------------|---|
| 1             | Study summary   |
| 2             | Methodology   |
| 3             | Group I: Coal and coke  |
| 4             | Group II: Petroleum fuels   |
| 5             | Group III: Crude Petrol.  |
| 6             | Group IV: Aggregates  |
| 7             | Group V: Grains   |
| 8             | Group VI: Chemicals and chemical fertilizers                      |
| 9             | Group VII: Ores and Minerals                                      |
| 10            | Group VIII: Iron ore, steel and iron                              |
| 11            | Group IX: Feed and food products, nec.                            |
| 12            | Group X: Wood and paper products                                  |
| 13            | Group XI: Petroleum products, nec.                                |
| 14            | Group XII: Rubber, plastics, nonmetallic, mineral, products, nec. |
| 15            | Group XIII: Nonferrous, metals and alloys, nec.                   |
| 16            | Group XIV: Manufactured products, nec.                            |
| 17            | Group XV: Other, nec.   |

Additionally, an Executive Summary is available as a separate document.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

9 Final. npt. 1

Volume 7 of 17

GROUP V, GRAINS.

⑥  
**PROJECTIONS OF DEMAND  
FOR  
WATERBORNE TRANSPORTATION,  
OHIO RIVER BASIN,  
1980, 1990, 2000, 2020, 2040.** Volume 7. ✓

Prepared for

**U.S. ARMY CORPS OF ENGINEERS  
OHIO RIVER DIVISION, HUNTINGTON DISTRICT**

Contract No. <sup>15</sup> DACW69-78-C-0136

by

**Robert R. Nathan Associates, Inc.  
Consulting Economists  
Washington, D.C.**

⑪  
**DECEMBER 1980**  
15 2321

|                     |              |                                     |
|---------------------|--------------|-------------------------------------|
| Accession For       |              |                                     |
| NTIS GRA&I          |              | <input checked="" type="checkbox"/> |
| DTIC TAB            |              | <input type="checkbox"/>            |
| Unannounced         |              | <input type="checkbox"/>            |
| Justification       |              |                                     |
| By _____            |              |                                     |
| Distribution/ _____ |              |                                     |
| Availability Codes  |              |                                     |
| Dist                | Avail and/or | Special                             |
| <b>A</b>            |              |                                     |

407669

116

A limited supply of this report is available at cost (please prepay, with checks payable to the United States Treasurer) from:

Division Engineer  
U.S. Army Engineer Division, Ohio River  
ATTN: ORDAS  
P.O. Box 1159  
Cincinnati, OH 45201

The price of the several documents of the report is as follows:

Executive Summary: no charge  
Volume 1: \$4.00  
Volumes 2, 3, 7  
and 10: \$3.00 each  
All Others: \$2.00 each

The entire set of 17 volumes: \$40.00

An unlimited supply of this report will soon be available from:

National Technical Information Service (NTIS)  
U.S. Department of Commerce  
5285 Port Royal Road  
Springfield, VA 22161

Library cataloging information:

Robert R. Nathan Associates, Inc.  
Projections of demand for waterborne  
transportation, Ohio River Basin, 1980,  
1990, 2000, 2020, 2040 / Prepared for  
the U.S. Army Corps of Engineers,  
Huntington District ... by Robert R.  
Nathan Associates, Inc., December 1980.  
Cincinnati, Ohio : U.S. Army Corps of  
Engineers, Ohio River Division, 1980.

17 v. : ill. ; 28 cm.

Contract DACW69-78-0136.

"...one of three independent but complementary  
studies of future freight traffic on the Ohio  
River Basin Navigation System."

CONTENTS: v.1. Study summary.--v.2.  
Methodology.--v.3. Commodity groups .

1. Shipping--Ohio River Basin. 2. Inland  
water transportation--Ohio River Basin--Statistics.  
3. Ohio River Basin. I. United States. Army.  
Corps of Engineers. Ohio River Division.  
II. United States. Army. Corps of Engineers.  
Huntington District. III. Title.

HE597.03N3

OCLC no. 7030444

## PREFACE

This Corps of Engineers report describes one of three independent but complementary studies of future freight traffic on the Ohio River basin navigation system. Each of the studies considers existing waterborne commerce and develops a consistent set of projections of future traffic demands for all of the navigable waterways of the basin. Each report contains information on past and present waterborne commerce in the basin with projections by commodity group and origin-destination areas from 1976 to either 1990 or 2040.

The three projections, in conjunction with other analytical tools and waterway system information, will be used to evaluate specific waterway improvements required to meet short and long-term navigation needs. The output from these studies will serve as input to Corps inland navigation simulation models to help analyze the performance and requirements for improvements of the Ohio River basin navigation system. These data will be used in current studies relating to improvements of Gallipolis Locks, the Monongahela River, the Upper Ohio River, the Kanawha River, the Lower Ohio River, and the Tennessee River, as well as for other improvements.

The reports on the three studies are referred to as the "CONSAD," the "BATTELLE," and the "NATHAN" reports. The latter and final report was completed in November 1980. It was prepared for the Corps of Engineers by Robert R. Nathan Associates, Inc., Consulting Economists, Washington D.C. This study encompasses the period 1976-2040, and is by far the most detailed of the three.

The "CONSAD" report, completed in January 1979, was prepared for the Corps by the CONSAD Research Corporation of Pittsburgh, Pennsylvania. The study and the 1976-1990 projected traffic demands discussed in that report were developed by correlating the historic waterborne commodity flows on the Ohio River navigation system, with various indicators of regional and national demands for the commodities. The demand variables which appeared to best describe the historic traffic pattern for each of the commodity groups was selected for projection purposes. The projected values for the demand variables are based upon the 1972 OBERS Series E Projections of National and Regional Economic Activity. The OBERS projections serve as national standards and were developed by the Bureau of Economic Analysis of the U.S. Department of Commerce, in conjunction with the Economic Research Service of the Department of Agriculture.

The "BATTELLE" report was completed in June 1979, and was prepared for the Corps by the Battelle Columbus Laboratories, Columbus, Ohio. The study and the 1976-1990 traffic projections discussed in that report were developed by surveying all waterway users in the Ohio River Basin through a combined mail survey and personal interview approach. The purpose of the survey was to obtain an estimate from each individual shipper of his future commodity

movements, by specific origins and destinations, as well as other associated traffic information. All identifiable waterway users were contacted and requested to provide the survey information. In addition, personal interviews were held with the major shippers. The responses were then aggregated to yield projected traffic demands for the Ohio River navigation system.

The "NATHAN" report presents the findings of a commodity resource inventory, a modal split analysis and a market demand analysis. The work included investigation and analyses of the production, transportation, and demand characteristics of each of the major commodities transported on the Ohio River and its tributaries. For each of 15 commodity groups, the demand for waterway transportation into, out of, and within the Ohio River basin was projected through the year 2040. A detailed study analysis and discussion for each commodity group is presented in 15 individually bound reports, supplemented by a methodology report. A Study Summary and an Executive Summary present appropriately abbreviated discussion and findings resulting from these analyses. The Study Summary aggregates the commodity group totals for each of the several projection periods and lists the total waterborne commerce for each of the 72 operational locks and dams in the Ohio River Basin.

The "NATHAN" report, "Projections of Demand for Waterborne Transportation, Ohio River Basin, 1980, 1990, 2000, 2020, 2040" consists of the following volumes:

| <u>Subject Title</u>  | <u>Number of<br/>Pages</u> | <u>Volume Number</u> |
|---|----------------------------|----------------------|
| Study Summary   | 220                        | 1                    |
| Methodology   | 118                        | 2                    |
| Group I: Coal and Coke  | 134                        | 3                    |
| Group II: Petroleum Fuels   | 66                         | 4                    |
| Group III: Crude Petroleum  | 42                         | 5                    |
| Group IV: Aggregates  | 64                         | 6                    |
| Group V: Grains   | 131                        | 7                    |
| Group VI: Chemicals and Chemical<br>Fertilizers                   | 90                         | 8                    |
| Group VII: Ores and Minerals                                      | 61                         | 9                    |
| Group VIII: Iron Ore, Steel and Iron                              | 104                        | 10                   |
| Group IX: Feed and Food Products, Nec.                            | 44                         | 11                   |
| Group X: Wood and Paper Products                                  | 61                         | 12                   |
| Group XI: Petroleum Products, Nec.                                | 38                         | 13                   |
| Group XII: Rubber, Plastic, Nonmetallic<br>Mineral Products, Nec. | 41                         | 14                   |
| Group XIII: Nonferrous Metals and Alloys,<br>Nec.                 | 57                         | 15                   |
| Group XIV: Manufactured Products Nec.                             | 35                         | 16                   |
| Group XV: Others, Nec.  | 48                         | 17                   |

Additionally, an Executive Summary is available as a separate document.





PROJECTIONS OF DEMAND FOR WATERBORNE  
TRANSPORTATION  
OHIO RIVER BASIN  
1980, 1990, 2000, 2020, 2040

Group V: Grains

Prepared for  
U.S. Army Corps of Engineers  
Huntington District  
Contract No. DACW69-78-C-0136

by  
Robert R. Nathan Associates, Inc.  
Consulting Economists  
Washington, D.C.

November 1980

## TABLE OF CONTENTS

|   | <u>Page</u> |
|---|-------------|
| I. INTRODUCTION.....  | 1           |
| A. Description of Commodity Group V.....  | 2           |
| B. Existing Waterway Traffic Flows.....   | 5           |
| B-1. BEA-to-BEA Waterway Flows.....   | 5           |
| B-2. Highlights of Important Links.....   | 9           |
| C. Summary of Study Findings.....   | 17          |
| II. MARKET DEMAND ANALYSIS.....   | 19          |
| A. Market Areas.....  | 19          |
| A-1. Primary Study Areas (PSAs).....  | 19          |
| A-2. Secondary Consumption Areas (SCAs).....  | 20          |
| A-3. The Export Market.....   | 23          |
| B. Commodity Uses.....  | 25          |
| B-1. Corn, Wheat, and Soybeans.....   | 25          |
| B-2. Minor Grains.....  | 28          |
| C. Consumption Characteristics.....   | 30          |
| C-1. Corn, Wheat, and Soybeans.....   | 31          |
| C-2. Minor Grains.....  | 38          |
| D. Existing Aggregate Demands.....  | 38          |
| D-1. Corn, Wheat, and Soybeans.....   | 39          |
| D-2. Minor Grains.....  | 47          |
| E. Forecasting Procedures and Assumptions.....  | 48          |
| E-1. U.S. Department of Agriculture: National<br>Interregional Agricultural Projections<br>Systems..... | 48          |
| E-2. Disaggregation of State Level Data<br>to BEA Level.....  | 51          |
| F. Probable Future Demands.....   | 52          |
| III. COMMODITY RESOURCES INVENTORY.....   | 55          |
| A. Production Areas.....  | 55          |
| B. Production Characteristics.....  | 56          |
| B-1. Corn, Wheat, and Soybeans.....   | 56          |
| B-2. Minor Grains.....  | 71          |
| C. Feedstocks (Available Cropland).....   | 77          |
| D. Existing Production Levels.....  | 78          |
| D-1. Corn, Wheat, and Soybeans.....   | 78          |

|  | <u>Page</u> |
|--|-------------|
| D-2. Minor Grains.....   | 80          |
| E. Forecasting Procedures and Assumptions.....   | 83          |
| E-1. U.S. Department of Agriculture: National -<br>Interregional Agricultural Projections<br>System (NIRAP).....   | 83          |
| E-2. Disaggregation of State Level Data to<br>BEA Level.....   | 84          |
| F. Probable Future Production Levels.....  | 85          |
| IV. TRANSPORTATION CHARACTERISTICS.....  | 89          |
| A. Existing Modal Split.....   | 89          |
| B. Intermodal Characteristics.....   | 91          |
| C. Factors Affecting Modal Choice.....   | 91          |
| C-1. Transport Costs and Distance.....   | 93          |
| C-2. Other Modal Choice Factors.....   | 94          |
| D. Forecasting Procedures and Assumptions.....   | 98          |
| D-1. Forecasting Procedures for BEA Waterway<br>Flows, 1980-2040.....  | 99          |
| D-2. Forecasting Procedures for Rail<br>Movements, 1980-2040.....  | 99          |
| D-3. Forecasting Procedures for Estimating<br>Truck Movements and PSAs Receipts<br>and Shipments for Waterborne Move-<br>ments for BEAs Exterior to the ORB..... | 100         |
| E. Probable Future Modal Split.....  | 100         |
| F. Probable Future Waterway Flows.....   | 103         |
| V. APPENDIX A.....   | 111         |
| VI. APPENDIX B.....  | 119         |
| VII. SOURCES AND REFERENCES.....   | 123         |

## I. INTRODUCTION

Commodity Group V consists of grains. In 1976, the Ohio River System (ORS) accounted for about 11 percent of the corn, 10 percent of the soybeans, and 12 percent of the wheat shipped on domestic waterways. Although grains represented only about 3 percent of total waterborne commerce in the ORS in 1976, they were one of the fastest growing waterborne commodity movements, flowing to and/or from almost every major port equivalent (PE) in the inland waterway system. Grains also provided one of the higher value and longer haul movements in the system.

The areas within the Ohio River Basin (ORB) for which projections of Group V consumption, production, and movements have been made are designated as Primary Study Areas (PSAs). The PSAs for Group V are those U.S. Department of Commerce, Bureau of Economic Analysis Areas (BEAs) and the area segments (aggregation of counties within a BEA) that are origins or destinations of Group V waterborne movements. A map showing Group V PSAs is presented in Appendix A to this report.

In addition to the PSAs, external areas linked to the ORB through waterborne commerce were identified. Areas (BEAs) outside the ORB that are destinations of waterborne grain movements originating in the ORB are designated as Secondary Consumption Areas (SCAs). Areas (BEAs) outside the ORB that are origins of Group V waterborne movements destined for the ORB are designated as Secondary Production Areas (SPAs).

Outbound waterway flows (traffic from a PE within the ORS to a PE outside the ORS) of grains originated principally on the Ohio

---

1. U.S. Army Corps of Engineers, Waterborne Commerce of the United States, 1976 ed. (New Orleans: COE, n.d.), Vol. V.

River. Outbound flows increased from 619.0 thousand tons in 1969 to 4.0 million tons in 1976. Inbound waterway flows, from PEs outside the ORS to PEs within the ORS, were destined principally for the Tennessee River. Inbound waterway flows decreased, in relative terms, from 12.1 percent of total waterborne movements in the ORS in 1969 to 4.8 percent in 1976. Local waterway flows (i.e., traffic from one PE to another within the ORS) remained relatively constant at 0.1 percent of total ORS movements.

A. Description of Commodity Group V

The individual products included in Group V are:

| <u>Waterborne<br/>Commerce<br/>Statistics<br/>Code (WCSC)</u> | <u>Product</u> |
|---|----------------|
| 0102  | Barley and rye |
| 0103  | Corn           |
| 0104  | Oats           |
| 0105  | Rice           |
| 0106  | Sorghum        |
| 0107  | Wheat          |
| 0111  | Soybeans.      |

The most important grains, in terms of total past and future ORS waterborne movements, are corn, wheat, and soybeans. In 1976, these grains accounted for 52.6, 26.1, and 20.0 percent of ORS waterborne grain traffic, respectively (Table 1). These three commodities accounted for between 94 and 99 percent of the waterborne movements of grains in the ORS between 1969-76.

The other four commodities had relatively small waterborne movements in the 1969-76 period -- between 1 and 6 percent of total waterborne grain traffic. Barley and rye movements were all inbound, destined for the Ohio River, and in general accounted for less than 1 percent of Group V waterborne movements. Oats, which accounted for about 3 percent of total ORS waterborne grain movements, were generally inbound and destined for the Tennessee River. Sorghum movements, which accounted for less than 1 percent of ORS grain traffic, were generally outbound from the Ohio River, destined for the lower Mississippi River.

During the base period, 1969-76, only one waterborne movement of rice occurred in the ORS. This was an inbound movement in 1974 that originated on the Arkansas River and was destined for Chattanooga, Tennessee.

Table 1. Ohio River System: Waterborne Shipments of Grains by Commodity, Inbound, Outbound and Local Movements, 1969-76

(Thousands of tons unless otherwise specified)

| Commodity and type of movement | 1969    | 1970    | 1971    | 1972    | 1973    | 1974    | 1975    | 1976    | Average annual percentage change, 1969-76 |
|--------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---|
| <u>Total</u>                   | 3,304.1 | 3,375.6 | 3,973.3 | 3,119.6 | 3,012.6 | 3,355.0 | 4,097.3 | 5,582.0 | 7.8                                       |
| Inbound                        | 2,532.8 | 2,823.7 | 2,919.3 | 1,912.6 | 1,740.0 | 1,742.3 | 1,368.1 | 1,418.0 | (8.0)                                     |
| Outbound                       | 619.2   | 422.4   | 928.9   | 1,092.2 | 1,102.0 | 1,497.3 | 2,609.0 | 4,035.0 | 30.7                                      |
| Local                          | 152.2   | 129.5   | 125.0   | 114.8   | 170.5   | 115.4   | 120.1   | 129.0   | (2.3)                                     |
| <u>Barley and rye</u>          | 46.8    | 36.7    | 36.7    | 41.6    | 11.3    | 6.9     | 11.1    | --      | a   |
| Inbound                        | 46.8    | 36.7    | 36.7    | 41.6    | 11.3    | 6.9     | 11.1    | --      | a   |
| Outbound                       | --      | --      | --      | --      | --      | --      | --      | --      | --  |
| Local                          | --      | --      | --      | --      | --      | --      | --      | --      | --  |
| <u>Corn</u>                    | 1,709.1 | 1,774.5 | 1,832.6 | 1,126.3 | 1,331.5 | 1,209.0 | 1,666.7 | 2,938.3 | 8.1                                       |
| Inbound                        | 1,452.1 | 1,540.0 | 1,534.4 | 832.6   | 789.6   | 682.5   | 376.5   | 263.7   | (21.6)                                    |
| Outbound                       | 179.6   | 178.1   | 262.8   | 267.8   | 491.9   | 505.4   | 1,263.5 | 2,639.4 | 46.8                                      |
| Local                          | 77.4    | 56.4    | 35.4    | 25.9    | 50.0    | 21.1    | 26.7    | 35.2    | (10.6)                                    |
| <u>Oats</u>                    | 73.3    | 78.2    | 158.6   | 128.0   | 81.2    | 98.1    | 48.4    | 59.7    | (2.9)                                     |
| Inbound                        | 65.9    | 78.2    | 158.6   | 128.0   | 81.2    | 97.1    | 45.8    | 37.7    | (7.7)                                     |
| Outbound                       | 6.1     | --      | --      | --      | --      | 1.0     | --      | 5.0     | (2.8)                                     |
| Local                          | 1.3     | --      | --      | --      | --      | --      | 2.6     | 17.0    | 44.4                                      |
| <u>Rice</u>                    | --      | --      | --      | --      | --      | 0.8     | --      | --      | a   |
| Inbound                        | --      | --      | --      | --      | --      | 0.8     | --      | --      | a   |
| Outbound                       | --      | --      | --      | --      | --      | --      | --      | --      | --  |
| Local                          | --      | --      | --      | --      | --      | --      | --      | --      | --  |
| <u>Sorghum</u>                 | 7.2     | 24.1    | 28.3    | 32.8    | 7.1     | --      | --      | 9.2     | 3.6                                       |
| Inbound                        | 7.2     | 22.6    | 10.7    | --      | --      | --      | --      | --      | a   |
| Outbound                       | --      | 1.5     | 17.6    | 32.8    | 4.6     | --      | --      | 9.2     | a   |
| Local                          | --      | --      | --      | --      | 2.5     | --      | --      | --      | a   |

(Continued)

Table 1. (Continued)

| Commodity and type<br>of movement | 1969  | 1970  | 1971    | 1972    | 1973  | 1974    | 1975    | 1976    | Average annual<br>percentage change,<br>1969-76 |
|-----------------------------------|-------|-------|---------|---------|-------|---------|---------|---------|---|
| <u>Wheat</u>                      | 787.4 | 796.7 | 1,006.6 | 1,050.4 | 688.1 | 1,044.0 | 1,342.6 | 1,458.4 | 9.2   |
| Inbound                           | 705.4 | 760.0 | 861.8   | 786.7   | 610.2 | 697.1   | 750.2   | 901.2   | 3.6   |
| Outbound                          | 58.5  | 12.5  | 143.5   | 259.4   | 60.7  | 332.5   | 568.8   | 538.9   | 37.3  |
| Local                             | 23.5  | 24.2  | 1.3     | 4.3     | 17.2  | 14.4    | 23.6    | 18.3    | (3.5)   |
| <u>Soybeans</u>                   | 680.2 | 665.5 | 910.6   | 740.5   | 893.3 | 996.3   | 1,028.6 | 1,117.1 | 7.3   |
| Inbound                           | 255.3 | 386.2 | 317.1   | 123.7   | 247.7 | 257.8   | 184.6   | 215.5   | (2.4)   |
| Outbound                          | 374.9 | 230.4 | 505.1   | 532.2   | 544.8 | 658.5   | 776.7   | 843.1   | 12.3  |
| Local                             | 50.0  | 48.9  | 88.4    | 84.6    | 100.8 | 80.0    | 67.3    | 58.5    | 2.3   |

Note: Individual items may not add to total due to rounding.

a. No tonnages reported in 1969 and/or 1976.

Source: Waterborne Commerce by Port Equivalents, 1969-76, supplied by the U.S. Army Corps of Engineers.

These four commodities (barley and rye, sorghum, oats, and rice) are not expected to move in the Ohio River System in significant quantities in the future. To the extent that they are produced in the PSAs at all, they often are consumed on the farm where grown and therefore are not generally shipped. Because of their insignificance in terms of waterway movements, these commodities have not been analyzed in depth during the course of this study. Group V historical and projected production and consumption do not include these minor grains.

#### B. Existing Waterway Traffic Flows

The total inbound, outbound, and local grain traffic in the ORS was recorded at 3.3 million tons in 1969, increasing to 5.6 million in 1976. Two distinct trends can be noted in regard to ORS waterborne grain movements. Outbound grain increased at an average annual rate of 30.7 percent, increasing the relative share of grains in total ORS outbound traffic from 3.9 percent in 1969 to 15.0 percent in 1976. The inverse was the case in regard to inbound movements, which decreased from 2.5 million tons in 1969 to 1.4 million in 1976, an average annual decrease of 8.0 percent. Local grain movements within the ORS remained relatively small and unchanged (Table 2).

##### B-1. BEA-to-BEA Waterway Flows

Between 1969 and 1976, total waterborne grain movements in the ORS increased at an average annual rate of 7.8 percent.

The most significant PSAs, in terms of the volume of outbound waterborne grain movements, were BEAs 55 (Evansville), 62 (Cincinnati), 49 (Nashville), 60 (Indianapolis), 63 (Dayton), and 115 (Paducah), which together accounted for over 90 percent of ORS outbound grain movements in 1976 (Table 3). Over 96 percent of the grain outbound from these six BEAs was destined for BEA 138 (New Orleans) for export via Gulf Coast ports.

In terms of inbound movements, the most significant PSAs were BEAs 48 (Chattanooga), 47 (Huntsville), 55 (Evansville), and 45 (Birmingham), which together accounted for over 97 percent of inbound movements to the PSAs in 1976 (Table 3). Over 83 percent of the inbound grain destined to these PSAs originated in BEAs 91 (Minneapolis), 111 (Kansas City), 77 (Chicago), 119 (Tulsa), and 78 (Peoria), all of which are served by the upper Mississippi River and the Illinois Waterway.



Table 2. Ohio River System: Waterborne Shipments of All Commodities and of Grains,  
1969 and 1976

(Thousands of tons unless otherwise specified)

|                                       | Total     |           | Inbound  |          | Outbound |          | Local     |           |
|---------------------------------------|-----------|-----------|----------|----------|----------|----------|-----------|-----------|
|                                       | 1969      | 1976      | 1969     | 1976     | 1969     | 1976     | 1969      | 1976      |
| All commodities                       | 159,835.8 | 200,770.5 | 21,001.1 | 29,439.5 | 16,071.1 | 26,854.0 | 122,763.6 | 144,477.0 |
| Grains                                | 3,304.1   | 5,582.0   | 2,532.8  | 1,418.0  | 619.2    | 4,035.0  | 152.2     | 129.0     |
| As a percentage of<br>all commodities | 2.1       | 2.8       | 12.1     | 4.8      | 3.9      | 15.0     | 0.1       | 0.1       |

Source: Waterborne Commerce by Port Equivalents, 1969 and revised 1976, supplied by the U.S. Army Corps of Engineers.

Table 3. Ohio River Basin: Waterborne Commerce by BEA, 1976  
Group 5: Grains  
(Thousands of tons)

| Origins             | Destinations |             |                        |                        |           |           |           |           |           |            |
|---------------------|--------------|-------------|------------------------|------------------------|-----------|-----------|-----------|-----------|-----------|------------|
|                     | Total        | ORB<br>BEAs | BEA <sup>a</sup><br>44 | BEA <sup>a</sup><br>45 | BEA<br>47 | BEA<br>48 | BEA<br>50 | BEA<br>55 | BEA<br>62 | BEA<br>115 |
| <b>Total</b>        | 5,582.0      | 1,547.0     | 26.3                   | 114.2                  | 420.8     | 807.9     | 11.1      | 163.6     | 1.1       | 2.0        |
| <b>ORB BEAs</b>     | 4,164.0      | 129.0       | 1.1                    | 17.2                   | 30.9      | 62.4      | 2.0       | 13.4      | 0         | 2.0        |
| 46 <sup>a</sup>     | 21.4         | 4.8         | --                     | 1.0                    | 1.9       | 1.9       | --        | --        | --        | --         |
| 49                  | 269.3        | 15.2        | --                     | 1.1                    | 2.3       | 4.8       | --        | 5.0       | --        | --         |
| 52 <sup>a</sup>     | 1.1          | 0           | --                     | --                     | --        | --        | --        | --        | --        | --         |
| 53 <sup>a</sup>     | 34.6         | 0           | --                     | --                     | --        | --        | --        | --        | --        | --         |
| 54                  | 113.8        | 10.0        | --                     | 2.4                    | 3.5       | 2.8       | --        | 1.3       | --        | --         |
| 55 <sup>a</sup>     | 1,907.8      | 54.1        | 1.1                    | 8.9                    | 11.2      | 30.9      | --        | --        | --        | 2.0        |
| 56 <sup>a</sup>     | 76.4         | 2.4         | --                     | --                     | 1.2       | 1.2       | --        | --        | --        | --         |
| 60 <sup>a</sup>     | 243.8        | 9.1         | --                     | 1.1                    | 3.1       | 3.5       | --        | 1.4       | --        | --         |
| 61 <sup>a</sup>     | 53.3         | 1.4         | --                     | --                     | --        | 1.4       | --        | --        | --        | --         |
| 62                  | 892.1        | 18.0        | --                     | 2.7                    | 4.2       | 7.6       | --        | 3.5       | --        | --         |
| 63 <sup>a</sup>     | 181.9        | 4.0         | --                     | --                     | 1.3       | 1.7       | --        | 1.0       | --        | --         |
| 64 <sup>a</sup>     | 76.9         | 2.7         | --                     | --                     | --        | 1.5       | --        | 1.2       | --        | --         |
| 114                 | 38.4         | 2.4         | --                     | --                     | 1.2       | 1.2       | --        | --        | --        | --         |
| 115                 | 251.2        | 4.9         | --                     | --                     | 1.0       | 3.9       | --        | --        | --        | --         |
| <b>Non-ORB BEAs</b> | 1,418.0      | 1,418.0     | 25.2                   | 97.0                   | 389.9     | 745.5     | 9.1       | 150.2     | 1.1       | 0          |
| 57                  | 11.8         | 11.8        | --                     | 1.4                    | 5.5       | 4.9       | --        | --        | --        | --         |
| 77                  | 147.5        | 147.5       | 2.6                    | 33.2                   | 60.3      | 51.4      | --        | --        | --        | --         |
| 78                  | 122.3        | 122.3       | 1.6                    | 23.2                   | 60.1      | 36.3      | --        | 1.1       | --        | --         |
| 79                  | 22.0         | 22.0        | --                     | 2.0                    | 6.4       | 11.6      | --        | 2.0       | --        | --         |
| 81                  | 1.1          | 1.1         | --                     | --                     | 1.1       | --        | --        | --        | --        | --         |
| 89                  | 6.4          | 6.4         | --                     | --                     | 3.3       | 3.1       | --        | --        | --        | --         |
| 91                  | 445.1        | 445.1       | 9.5                    | 14.6                   | 68.7      | 290.3     | 5.8       | 56.2      | --        | --         |
| 103                 | 3.3          | 3.3         | --                     | --                     | --        | 2.2       | --        | 1.1       | --        | --         |
| 107                 | 13.2         | 13.2        | --                     | 1.0                    | 5.7       | 6.5       | --        | --        | --        | --         |
| 108                 | 1.1          | 1.1         | --                     | --                     | --        | 1.1       | --        | --        | --        | --         |
| 111                 | 383.9        | 383.9       | 6.7                    | 4.1                    | 63.8      | 219.3     | 1.1       | 88.9      | --        | --         |
| 112                 | 1.1          | 1.1         | --                     | --                     | 1.1       | --        | --        | --        | --        | --         |
| 113 <sup>b</sup>    | 25.8         | 25.8        | 1.2                    | 6.0                    | 9.5       | 9.1       | --        | --        | --        | --         |
| 114 <sup>b</sup>    | 134.9        | 134.9       | 1.1                    | 11.5                   | 100.2     | 22.1      | --        | --        | --        | --         |
| 115 <sup>b</sup>    | 6.4          | 6.4         | --                     | --                     | 2.0       | 3.3       | 1.1       | --        | --        | --         |
| 117                 | 1.1          | 1.1         | --                     | --                     | --        | --        | --        | --        | --        | --         |
| 119                 | 85.7         | 85.7        | 2.5                    | --                     | --        | 82.1      | --        | --        | --        | --         |
| 134                 | 2.2          | 2.2         | --                     | --                     | --        | 2.2       | --        | --        | --        | --         |
| 138                 | 1.1          | 1.1         | --                     | --                     | --        | --        | --        | --        | --        | --         |
| 141                 | 2.0          | 2.0         | --                     | --                     | 1.1       | --        | --        | 2.0       | --        | --         |

(Continued)

Table 3. (Continued)

| Origins          | Destinations    |           |                        |            |                         |            |            |            |            |            |            |            |
|------------------|-----------------|-----------|------------------------|------------|-------------------------|------------|------------|------------|------------|------------|------------|------------|
|                  | Non-ORB<br>BEAs | BEA<br>38 | BEA <sup>b</sup><br>46 | BEA<br>111 | BEA <sup>b</sup><br>114 | BEA<br>117 | BEA<br>133 | BEA<br>137 | BEA<br>138 | BEA<br>140 | BEA<br>141 | BEA<br>143 |
| Total            | 4,035.0         | 4.4       | 19.1                   | 2.2        | 17.8                    | 1.0        | 2.2        | 76.1       | 3,896.0    | 3.1        | 10.1       | 3.0        |
| ORB BEAs         | 4,035.0         | 4.4       | 19.1                   | 2.2        | 17.8                    | 1.0        | 2.2        | 76.1       | 3,896.0    | 3.1        | 10.1       | 3.0        |
| 46 <sup>a</sup>  | 16.6            | --        | --                     | 1.0        | --                      | --         | --         | 2.9        | 12.7       | --         | --         | --         |
| 49               | 254.1           | 1.1       | --                     | 1.2        | --                      | --         | --         | 4.7        | 247.1      | --         | --         | --         |
| 52               | 1.1             | --        | --                     | --         | --                      | --         | --         | --         | --         | --         | 1.1        | --         |
| 53 <sup>a</sup>  | 34.6            | --        | 1.0                    | --         | --                      | --         | --         | 1.1        | 32.5       | --         | --         | --         |
| 54               | 103.8           | --        | --                     | --         | --                      | --         | --         | --         | 103.8      | --         | --         | --         |
| 55               | 1,853.7         | 2.0       | 5.9                    | --         | 9.2                     | --         | --         | 41.6       | 1,782.6    | 3.1        | 6.3        | 3.0        |
| 56 <sup>a</sup>  | 74.0            | --        | --                     | --         | --                      | --         | --         | 2.0        | 72.0       | --         | --         | --         |
| 60 <sup>a</sup>  | 234.7           | --        | 1.4                    | --         | 1.1                     | --         | --         | 3.1        | 229.1      | --         | --         | --         |
| 61 <sup>a</sup>  | 51.9            | --        | --                     | --         | --                      | --         | --         | 1.0        | 50.9       | --         | --         | --         |
| 62               | 874.1           | 1.3       | 6.9                    | --         | 4.2                     | --         | 1.2        | 14.5       | 846.0      | --         | --         | --         |
| 63 <sup>a</sup>  | 179.9           | --        | 1.4                    | --         | 1.1                     | --         | --         | 3.0        | 174.4      | --         | --         | --         |
| 64 <sup>a</sup>  | 74.2            | --        | --                     | --         | --                      | --         | --         | 1.2        | 73.0       | --         | --         | --         |
| 114              | 36.0            | --        | 1.0                    | --         | 1.1                     | --         | --         | --         | 33.9       | --         | --         | --         |
| 115              | 246.3           | --        | 1.5                    | --         | 1.1                     | 1.0        | 1.0        | 1.0        | 238.0      | --         | 2.7        | --         |
| Non-ORB BEAs     |                 |           |                        |            |                         |            |            |            |            |            |            |            |
| 57               |                 |           |                        |            |                         |            |            |            |            |            |            |            |
| 77               |                 |           |                        |            |                         |            |            |            |            |            |            |            |
| 78               |                 |           |                        |            |                         |            |            |            |            |            |            |            |
| 79               |                 |           |                        |            |                         |            |            |            |            |            |            |            |
| 81               |                 |           |                        |            |                         |            |            |            |            |            |            |            |
| 89               |                 |           |                        |            |                         |            |            |            |            |            |            |            |
| 91               |                 |           |                        |            |                         |            |            |            |            |            |            |            |
| 103              |                 |           |                        |            |                         |            |            |            |            |            |            |            |
| 107              |                 |           |                        |            |                         |            |            |            |            |            |            |            |
| 108              |                 |           |                        |            |                         |            |            |            |            |            |            |            |
| 111              |                 |           |                        |            |                         |            |            |            |            |            |            |            |
| 112              |                 |           |                        |            |                         |            |            |            |            |            |            |            |
| 113              |                 |           |                        |            |                         |            |            |            |            |            |            |            |
| 114 <sup>b</sup> |                 |           |                        |            |                         |            |            |            |            |            |            |            |
| 115 <sup>b</sup> |                 |           |                        |            |                         |            |            |            |            |            |            |            |
| 117              |                 |           |                        |            |                         |            |            |            |            |            |            |            |
| 119              |                 |           |                        |            |                         |            |            |            |            |            |            |            |
| 134              |                 |           |                        |            |                         |            |            |            |            |            |            |            |
| 138              |                 |           |                        |            |                         |            |            |            |            |            |            |            |
| 141              |                 |           |                        |            |                         |            |            |            |            |            |            |            |

\*\* Traffic external to the Ohio River System \*\*

\*\* Traffic external to the Ohio River System \*\*

a. A non-waterside BEA origin or destination for waterborne traffic originating from or destined to port equivalents in the Ohio River System.

b. Waterborne traffic originating from or destined to port equivalents not located in the Ohio River System. Source: U.S. Army Corps of Engineers, Waterborne Commerce by Port Equivalents, revised 1976.

Within the ORS hinterland, other PSAs shipped and received smaller amounts than the above-mentioned BEAs. It is expected that this pattern will remain relatively unchanged. Those BEAs that ship are, and will continue to be, major production points. Most ORS hinterland receivers are waterside grain processors who are and will be servicing the large southeastern livestock production market.

In 1976, over 16 percent of outbound waterborne grain flows originated in non-waterside BEAs, and about 9 percent of inbound flows were destined to non-waterside BEAs (Table 3).

B-2. Highlights of Important Links

Of the 5.5 million tons of grains transported in the ORS in 1976, 40 million tons (over 70 percent) were outbound shipments. Inbound shipments accounted for 25 percent of ORS Group V traffic. Less than 2 percent of the traffic was local to the ORS.

a. Local movements

Local movements of grain within the ORS have been and are expected to remain insignificant relative to total Group V waterborne movements. Local movements amounted to 129.0 thousand tons in 1976, about 2.3 percent of Group V waterborne traffic. The Ohio River was the origin for about 85 percent of the ORS local traffic. Most local traffic was destined for the Tennessee River (Table 4).

Given that grain is a long-haul, high value-to-weight commodity (with an average waterway haul well over 1,000 miles), it is expected that local shipments will remain relatively insignificant.

b. Inbound movements

Inbound waterborne movements of grain to the ORS decreased dramatically between 1969-76, in terms of both total ORS waterborne grain movements and total ORS inbound movements of all commodities. In 1969, inbound movements accounted for more than 75 percent of ORS waterborne grain movements. By 1976, this percentage had decreased to 25 percent.

The Tennessee River was the principal destination for inbound grain. Between 1969-76, approximately 90 percent of grain inbound

---

1. U.S. Army Corps of Engineers, Waterborne Commerce of the United States, 1976 ed. (New Orleans: COE, n.d.), Vol. V.

Table 4. Ohio River System: Waterborne Receipts of Grains,  
by River of Origin and River of Destination, 1976

(Thousands of tons)

| Origins                          | Destinations |            |                 |
|----------------------------------|--------------|------------|-----------------|
|                                  | Total        | Ohio River | Tennessee River |
| Total                            | 1,547.0      | 165.9      | 1,381.1         |
| <u>Ohio River System</u>         | 129.0        | 14.6       | 114.4           |
| Green River                      | 5.0          | 5.0        | --              |
| Ohio River                       | 109.0        | 9.6        | 99.4            |
| Tennessee River                  | 15.0         | --         | 15.0            |
| <u>Outside Ohio River System</u> | 1,418.0      | 151.3      | 1,266.7         |
| Arkansas River                   | 85.7         | --         | 85.7            |
| Gulf Intercoastal Waterway       | 2.0          | 2.0        | --              |
| Illinois Waterway                | 298.7        | 1.1        | 297.6           |
| Lower Mississippi River          | 7.5          | --         | 7.5             |
| Missouri River                   | 402.6        | 90.0       | 312.6           |
| Upper Mississippi River          | 620.4        | 58.2       | 562.2           |
| White River                      | 1.1          | --         | 1.1             |

Source: U.S. Army Corps of Engineers, Waterborne Commerce by Port Equivalents, revised 1976.

to the ORS was destined for the Tennessee River. Of the 1.4 million tons of grain received on the Tennessee in 1976, 1.3 million, or 92 percent, originated outside the ORS; 99.4 thousand tons originated on the Ohio, and 15.0 thousand tons originated on the Tennessee River (Table 4). This pattern remained relatively constant over time. However, the amount of grain destined for the Tennessee that originated within the ORS (i.e., on the Ohio and the Tennessee Rivers) increased from 3 percent of total Tennessee River receipts in 1969 to over 8 percent in 1976.

Total waterborne movements to the Tennessee decreased almost 50 percent in volume between 1969 and 1976, from 2.5 million to 1.4 million tons. In 1969, inbound grain destined for the Tennessee came principally from the Illinois Waterway and the upper Mississippi River. By 1976, the importance of these two rivers as origins for inbound movements to the Tennessee decreased (Table 4).

Wheat was the predominant inbound grain and consisted of hard wheat from Kansas that originated on the Missouri River, and spring wheat from Minnesota that originated on the upper Mississippi. These wheats are not grown in the PSAs and are necessary in the blending of wheats for the production of flour. Flour mills were the major wheat recipients.

In 1976, corn accounted for about 19 percent of inbound grain traffic and was destined primarily for feed manufacturers on the Tennessee River. Soybeans accounted for over 15 percent of total inbound grain traffic in 1976 and were destined for soyameal and oil processing plants on the Tennessee.

The Ohio River, the only ORS river other than the Tennessee to receive grain, received between 7 and 11 percent of total grain inbound to the ORS between 1969-76. Grain inbound to the Ohio River was destined principally for three PEs and was a type not grown locally in the ORS hinterland. These grains were hard red winter and durum spring wheats, destined for flour mills, and barley and rye, destined for Kentucky and Indiana for use by distillers in the production of whiskey.<sup>1</sup> Between 1969-76, no grain movements were destined for the Monongahela, Allegheny, Kanawha, Cumberland, Kentucky, Green, or Clinch/Emory Rivers or to the Barkley Canal.

---

1. According to the Annual Statistical Review, 1977 ed., of the Distilled Spirits Council of the United States, Kentucky and Indiana produced over 80 percent of all whiskeys produced in the United States in 1976.

Inbound grain flows to the Tennessee River, and the ORS in general, decreased as grain production in states adjacent to the ORS increased and as Tennessee area consumption decreased. In addition, the strength of the Gulf export market made it relatively unattractive for a barge originating on the upper Mississippi or the Illinois Waterway to divert into the ORS.

c. Outbound movements

Outbound waterborne movements of grains from the ORS increased over 550 percent between 1969-76, at an average annual growth rate of 30.7 percent. This increase, from 619.2 thousand tons in 1969 to 4.0 million tons in 1976, can be attributed to the growth in the PSAs' production to meet growing domestic and export demand.

In general, ORS outbound waterborne grain flows between 1969 and 1976 were concentrated on the Ohio River, which accounted for more than 90 percent of the outbound flows. A major portion of the Ohio River's grain shipments, over 86 percent in 1976, originated on the Mt. Vernon-Cincinnati corridor. During the period, outbound flows also originated on the Cumberland, Green, and Tennessee Rivers (Table 5).

As shown in Tables 5 and 6, the lower Mississippi River was the most important destination for Ohio River outbound traffic in both absolute and relative terms. In 1969, the Baton Rouge-New Orleans export market of the lower Mississippi River received 553.7 thousand tons, or 75 percent, of the Ohio River's outbound movements. By 1976, the lower Mississippi's receipt of Ohio River movements increased more than 550 percent to about 3.6 million tons, or over 97 percent of the Ohio's outbound movements.

The past and future significance of the Ohio River is linked to two factors. First, it is bordered by those PSAs in the ORS hinterland in which growth in grain production has historically been concentrated. Second, the Ohio River has the best developed facilities to handle waterborne grain, with barge-loading facilities with good rail and truck route interchanges.

The lower Mississippi was important to the waterborne movements of grain in the ORS in general. Its export market strength drew outbound movements from the ORS and diverted inbound movements. In addition to flows from the Ohio River, the lower Mississippi attracted grain from the Cumberland, Green, and Tennessee Rivers.

Table 5. Ohio River System: Waterborne Shipments of Grains,  
by River of Destination and River of Origin, 1976

(Thousands of tons)

| Destinations               | Origins |                     |                |               |
|----------------------------|---------|---------------------|----------------|---------------|
|                            | Total   | Cumberland<br>River | Green<br>River | Ohio<br>River |
| Total                      | 4,164.0 | 12.0                | 176.0          | 3,840.4       |
| Ohio River System          | 129.0   | 0                   | 5.0            | 109.0         |
| Ohio River                 | 14.6    | --                  | 5.0            | 9.6           |
| Tennessee River            | 114.4   | --                  | --             | 99.4          |
| Outside Ohio River System  | 4,035.0 | 12.0                | 171.0          | 3,731.4       |
| Gulf Intercoastal Waterway | 86.2    | --                  | 1.0            | 78.6          |
| Houston Ship Channel       | 6.1     | --                  | --             | 6.1           |
| Lower Mississippi River    | 3,917.3 | 12.0                | 170.0          | 3,624.6       |
| Missouri River             | 2.2     | --                  | --             | --            |
| Mobile River               | 4.4     | --                  | --             | 3.3           |
| Upper Mississippi River    | 17.8    | --                  | --             | 17.8          |
| White River                | 1.0     | --                  | --             | 1.0           |
| Tennessee River            | 135.6   | --                  | --             | --            |

Source: U.S. Army Corps of Engineers, Waterborne Commerce by Port Equivalents,  
revised 1976.



Table 6. Ohio River System: Waterborne Grain Shipments to the Lower Mississippi River, by Ohio River System Origin, 1969-76

(Thousands of tons unless otherwise specified)

| Ohio River System origin | 1969  | 1970  | 1971  | 1972  | 1973  | 1974    | 1975    | 1976    | Average annual percentage change, 1969-76 |
|--------------------------|-------|-------|-------|-------|-------|---------|---------|---------|---|
| Total                    | 567.8 | 354.5 | 844.8 | 941.7 | 994.3 | 1,381.7 | 2,368.1 | 3,917.3 | 31.8                                      |
| Cumberland               | --    | --    | --    | 6.1   | 11.4  | 15.6    | 3.8     | 12.0    | 18.4 <sup>a</sup>                         |
| Green                    | --    | 1.3   | 46.0  | 44.8  | 48.4  | 77.6    | 90.1    | 170.0   | 125.3 <sup>b</sup>                        |
| Ohio                     | 553.7 | 338.8 | 775.4 | 882.1 | 912.3 | 1,270.2 | 2,238.1 | 3,624.6 | 30.8                                      |
| Tennessee                | 14.1  | 14.4  | 23.4  | 8.8   | 22.2  | 18.3    | 36.1    | 110.7   | 34.2                                      |

Note: Individual items may not add to total due to rounding.

a. Percentage change computed for 1972-76.

b. Percentage change computed for 1970-76.

Source: Waterborne Commerce by Port Equivalents, 1969-76, supplied by U.S. Army Corps of Engineers.

Table 6, which indicates total shipments from the ORS to the lower Mississippi between 1969 and 1976, shows the tremendous growth in lower Mississippi grain receipts from the ORS, at an average annual rate of 31.8 percent. The Green River's shipments to the lower Mississippi grew the fastest of any ORS river, followed by the growth of the Tennessee. Relatively, however, the Ohio River has been and is expected to remain the most significant ORS outbound shipper of grains to all destinations and particularly to the lower Mississippi.

The importance of corn, wheat, and soybeans in terms of outbound waterborne traffic from the ORS to the lower Mississippi is indicated in Table 7. Corn, wheat, and soybeans accounted for 98.7 percent of the lower Mississippi's receipts from the ORS in 1969, and for 99.7 percent in 1976. The growth in corn and wheat movements was phenomenal, most notably between 1974-76. As of 1976, corn was the predominant grain of the three.

Intermodal transfers of Group V products are common in the ORS hinterland in terms of truck-barge and truck-rail transfers, but rare in terms of rail-barge transfers.

The system by which grain flows from the grain surplus areas of Ohio, Illinois, and Indiana to the grain deficient areas of the South (Tennessee, Kentucky, Georgia, Mississippi, and Alabama) is complex and interactive. Grain moves by truck from one farm to another, or to country elevators that collect and merchandise grain. It then moves to consumption destinations by truck and rail. Riverside elevators receive grain by truck, both directly from the farm and from country elevators. The radius of a river-side elevator's drawing area served by truck ranges from 150 to 200 miles. These elevators have limited storage capacities and high turnover rates and generally have both rail and barge links, as well as rail and barge loading facilities. Multimode capability allows the larger elevators flexibility in responding to various market demands and price situations.

Discussions with industry experts and ORS shippers indicate that rail-to-barge or barge-to-rail links are rare and are generally in response to short-term cyclical market conditions. It may become profitable for a waterborne receiver (grain merchandiser) with a rail link to send grain receipts to a market where prices are more favorable because of higher than usual demand.

Table 7. Ohio River System: Waterborne Grain Shipments to the Lower Mississippi River, by Grain Type, Selected Years, 1969-76  
(Thousands of tons unless otherwise specified)

|                    | 1969  | 1971  | 1973  | 1974    | 1976    | Average annual<br>percentage change,<br>1969-76 |
|--------------------|-------|-------|-------|---------|---------|---|
| Corn               | 166.5 | 252.3 | 470.2 | 482.8   | 2,607.0 | 48.1  |
| Soybeans           | 353.7 | 472.6 | 489.9 | 610.5   | 789.7   | 12.2  |
| Wheat              | 40.2  | 101.4 | 28.7  | 284.3   | 508.6   | 43.7  |
| Other <sup>a</sup> | 7.4   | 18.5  | 5.5   | 4.1     | 12.0    | 7.2   |
| Total              | 567.8 | 844.8 | 994.3 | 1,381.7 | 3,917.3 | 31.8  |

Note: Individual items may not add to total due to rounding.

a. Other includes barley and rye, oats, rice and sorghum.

Source: Waterborne Commerce by Port Equivalents, 1969-76, supplied by U.S. Army Corps of Engineers.

### C. Summary of Study Findings

The consumption of grain in the PSAs decreased at a annual rate of 0.86 percent between 1969-76. Total grain consumption, by each of the three end uses of grain (livestock feed, processing, and seed), decreased from 23.5 million tons in 1969 to 22.1 million tons in 1976. Grain consumed by livestock, representing on the average 75 percent of total consumption during the period, accounted for most of this decrease.

In the future, grain consumption is expected to increase at a gradual and steady rate of 0.54 percent per annum between 1976-2000. Total consumption of grain in the PSAs is expected to reach 22.4 million tons in 1980 and 23.3 million tons in 1990. Beyond 2000, grain consumption is expected to increase at a decreasing rate, reaching a level of 27.1 million tons in 2040. Corn will be the predominant grain consumed, and livestock will remain the major consumer of all grain.

Between 1969-76, the production of grain in the PSAs increased at an average annual rate of 7.0 percent. Although production was concentrated in PSAs in Indiana, Illinois, and Ohio, the greatest growth was experienced in the PSAs in the southern states. The PSAs' grain production growth exceeded U.S. production increases, and during this period the PSAs increased their relative share of U.S. total production of corn, wheat, and soybeans. The PSAs' grain production increased from 15.9 million tons in 1969, 7.7 percent of U.S. production, to 25.6 million tons, approximately 9.2 percent of U.S. production. The production mix remained relatively stable over time, with corn representing approximately 74 percent of ORS hinterland's total production of corn, wheat, and soybeans. Of these three grain types, soybeans represented about 18 percent of grain production in the PSAs, and wheat represented about 8 percent of production.

Grain production in the PSAs is expected to increase at a annual rate of 1.01 percent between 1976 and 2000. A notable decrease is expected to occur between 1976 and 1980, when production will drop more than 20 percent from 25.6 million tons to 19.9 million tons. This projected decrease is based on anticipated decreases in the production of corn. Most of this decrease is projected to occur in the southern section of the ORS hinterland, specifically Tennessee and Kentucky.

Decreases in future grain production in the PSAs can be attributed to reduction in corn acreage. Because of declining prices, farmers are expected to either enter the feed grain program or plant soybeans, a more profitable crop. Each acre of planted corn produced 87.9 bushels in the ORS hinterland in 1976, and each acre of soybeans produced 29.9 bushels. By planting soybeans rather than corn, each acre will produce fewer tons of grain. Thus the total grain production (in terms of tonnage) for the PSAs is expected to decline.

Beyond 1980, grain production in the PSAs is expected to increase, reaching a level of 25.2 million tons in 1990 and rising to 46.4 million tons in 2040. BEAs 49 (Nashville), 54 (Louisville), 55 (Evansville), 60 (Indianapolis), 62 (Cincinnati), 63 (Dayton), 64 (Columbus), and 115 (Paducah) are expected to remain the prime ORS hinterland production areas.

In 1976, waterway movements of grain totalled 5.6 million tons for the ORS. Of this total, 4.0 million tons were outbound movements, 1.4 million tons were inbound, and 129 thousand tons were local. Beginning in 2000, the margin between ORS hinterland grain production and consumption is expected to widen, and more grain will be available for shipment. As of 2000, of the total amount of grain available for shipment, approximately twice as much will be shipped out of the hinterland by rail as by water.

Between 1976 and 1980, waterway flows are expected to decrease, dropping from a 1976 level of 5.6 million tons to 4.2 million tons. After 1980, waterway movements are expected to increase steadily to 6.0 million tons by 2000 and to 8.6 million tons by 2040. Over the entire period 1976-2040, inbound waterborne movements are expected to decrease at an average annual rate of 0.52 percent. However, outbound movements are expected to increase an average 0.95 percent per annum, and local movements are expected to increase at a rate slightly faster than outbound but to remain small relative to total waterborne grain movements in the ORS.

## II. MARKET DEMAND ANALYSIS

Projections of future grain consumption in the PSAs generally have been based on assumptions about the future that underlie analyses and projections of the U.S. Department of Agriculture (USDA). As the premier agricultural research entity in the United States, USDA has resources and experience that could not be duplicated by this study.

Consumption of grains in the PSAs decreased slightly between 1969-76, from 23.5 million tons to 22.1 million tons. Consumption decreased most rapidly in those PSAs that were the largest producing areas. Consumption is accounted for by three end uses: livestock feed, processing, and seed. Between 1969-76, livestock consumption accounted for approximately 75 percent of total grain consumption, processing accounted for approximately 23 percent, and seed for about 2 percent. This pattern of consumption is expected to remain relatively constant. Consumption of grains in the PSAs is expected to increase by 14 percent between 1976 and 2000, and by 8 percent between 2000 and 2040.

### A. Market Areas

In addition to local demand for Group V commodities produced in the PSAs, demand is generated by Secondary Consumption Areas (SCAs) located outside the ORB. These SCAs are defined as BEAs that are the destinations of waterborne movements originating in the Ohio River Basin.

#### A-1. Primary Study Areas (PSAs)

This study has identified 19 BEAs and BEA segments in the ORB that either have been or will be the ultimate origins or destinations of waterborne grain movements. Table A-1 presents the BEAs

and BEA segments that constitute the PSAs for grains, and for which grain consumption has been analyzed and projected.

The delineation of the Primary Study Areas for grains was the result of an extensive and thorough process. RRNA, in conjunction with a grain commodity expert familiar with the region, considered a series of PSA delineations of likely hinterlands based on surplus production, distance from the river, waterside facilities, and physical barriers. The accuracy of the PSA hinterland chosen was confirmed by conversations with major ORS shippers and receivers.

A-2. Secondary Consumption  
Areas (SCAs)

BEAs outside the Ohio River Basin that are destinations of waterborne grain shipments from the ORS hinterland have not been segmented. It should be recognized that many of these destination BEAs are not the points of ultimate consumption for grains produced in the PSAs. Rather, they are distribution centers from which grain moves into foreign (export) trade or to other areas where final consumption occurs.

Much of the grain produced and shipped from Illinois, Indiana, and Ohio (the primary producing states in the area served by the ORS) is destined for southern states and for export abroad (Table 8). The northeast market generally is served by Ohio production. The northeastern states that are destinations of production from these three "Corn Belt" states are New York, Pennsylvania, and New Hampshire. This northeastern market is served by truck and rail. The western market accounted for less than 1 percent of interstate shipments from Illinois, Indiana, and Ohio in 1970.

Of the grain produced in and shipped from Ohio, Illinois, and Indiana in 1970, more than 37 percent was destined for the South (Table 8). The state-level distribution pattern of grain shipped to the South from the latter three states is shown in Table 9.

The southern states are the primary domestic market for grain grown in the PSAs. These states, in general, are deficit feed grain areas, with large grain-consuming animal industries, mainly poultry. Although these states may have harvest time surpluses sufficient to handle area demand temporarily, throughout the year they are generally net importers.

Over 80 percent of interstate grain received by the five southern states of Alabama, Georgia, Kentucky, Mississippi, and

Table 8. Illinois, Indiana and Ohio Grain Shipments by Destination, 1970  
(Thousands of bushels unless otherwise specified)

| Origins                                       | Destinations           |       |           |         |         | Total interstate shipments |
|---|------------------------|-------|-----------|---------|---------|----------------------------|
|   | Other corn belt states | West  | Northeast | South   | Export  |                            |
| Illinois                                      | 85,002                 | 7,710 | 9,860     | 282,753 | 281,712 | 667,037                    |
| Indiana                                       | 103,805                | 20    | 15,285    | 103,611 | 137,745 | 360,466                    |
| Ohio  | 20,928                 | --    | 43,780    | 78,258  | 83,580  | 226,546                    |
| Total   | 209,735                | 7,730 | 68,925    | 464,622 | 503,037 | 1,254,049                  |
| As a percentage of total interstate shipments | 16.6                   | 0.6   | 5.5       | 37.1    | 40.1    | 100.0                      |

Source: Stallings, T. L., Harris, J. M. and Sappington, C. Grain Movements Between Southern and Corn Belt States, Southern Cooperative Series, Bulletin No. 209, March 1976.



Table 9. Indiana and Ohio Grain Shipments Destined to the South,  
by State, 1970

(Thousands of bushels unless otherwise specified)

| Origins   | PSA state <sup>a</sup> | Destinations                |                               |           |           | Total South   |
|---|------------------------|-----------------------------|-------------------------------|-----------|-----------|---------------|
|   |                        | North and<br>South Carolina | Virginia and<br>West Virginia | Florida   | Louisiana |               |
| Illinois  | 258,314                | 1,739                       | --                            | 9,334     | 13,366    | 282,753       |
| Indiana   | 97,071                 | 4,424                       | 362                           | 1,754     | --        | 103,611       |
| Ohio  | <u>21,161</u>          | <u>26,764</u>               | <u>30,298</u>                 | <u>35</u> | <u>--</u> | <u>78,258</u> |
| Total   | 376,546                | 32,927                      | 30,660                        | 11,123    | 13,366    | 464,622       |
| As a percentage of<br>total interstate<br>shipments to the<br>South | 81.0                   | 7.1                         | 6.6                           | 2.4       | 2.9       | 100.0         |

a. Alabama, Georgia, Kentucky, Mississippi and Tennessee.  
Source: Stallings, J. L., Harris, J. M. and Sappington, C. Grain Movements Between  
Southern and Corn Belt States, Southern Cooperative Series, Bulletin No. 209, March 1976.

Tennessee originated in Ohio, Illinois, and Indiana. Grain produced and shipped from these states was destined for other southern states, but in relatively small amounts (Table 10).

### A-3. The Export Market

Forty percent of the grain (over 500 million bushels) produced and shipped from Indiana, Illinois, and Ohio in 1970 was destined for export points and shipped by rail and/or water (Table 9). The Toledo and Chicago export centers of the Great Lakes drew grain from the three ORS hinterland "Corn Belt" states; Chicago drawing from northern Illinois and northeast Indiana, and Toledo from central and northwest Indiana and north central Ohio.

In addition to Toledo, the Gulf Coast ports and the Port of Baltimore are important export centers for ORS hinterland grain, and for export-bound Corn Belt grain in general. Baltimore receives grain by rail from the Midwest and serves the European market, primarily the Netherlands, West Germany, Italy, the United Kingdom, and Spain. Midwest and ORS hinterland grain also is railed to Norfolk, Charleston, and Mobile for export.

In terms of U.S. waterborne grain traffic, the Baton Rouge-New Orleans area received over 90 percent of the corn, 97 percent of the soybeans, and 40 percent of the wheat that originated from identified shipping areas on the inland waterways between 1970-74.<sup>2</sup> The Baton Rouge-New Orleans area is expected to continue to provide a strong market for surplus ORS hinterland grain production. In 1976, the Baton Rouge-New Orleans area exported 43.6 million tons of the approximately 104 million tons of grain exported from the United States.<sup>3</sup> The Ohio River System accounted for about 10

---

1. The Great Lakes accounted for approximately 8 percent (8.7 million tons) of U.S. grain exports in 1976. U.S. Army Corps of Engineers, Waterborne Commerce of the United States, 1976 ed. (New Orleans: COE, n.d.), Vol. V.

2. U.S. Department of Agriculture, Economic Research Service, Water Carriers and Inland Waterways in Agricultural Transportation, Agricultural Economic Report No. 379, by Floyd D. Gaibler (Washington, D.C.: USDA, 1977).

3. U.S. Army Corps of Engineers, Waterborne Commerce of the United States, 1976 ed. (New Orleans: COE, n.d.) Vol. V. The ports of New Orleans and Baton Rouge accounted for approximately 40 percent of U.S. grain exports in 1976. The amount of PSA grain destined for export via other ports, coastal or Great Lakes, is unknown.

Table 10. Alabama, Georgia, Kentucky, Tennessee Grain Receipts by Origin, 1970  
(Thousands of bushels unless otherwise specified)

| Destinations                                 | Origins            |          |         |        |        |          |           |        |                     | Total interstate receipts |
|--|--------------------|----------|---------|--------|--------|----------|-----------|--------|---------------------|---------------------------|
|  | 12 southern states | Illinois | Indiana | Ohio   | Iowa   | Missouri | Minnesota | Kansas | Others <sup>a</sup> |                           |
| Alabama                                      | 4,209              | 67,479   | 9,177   | 1,094  | 4,263  | 3,609    | 10,610    | 1,501  | --                  | 101,942                   |
| Georgia                                      | 23,121             | 60,771   | 24,222  | 1,708  | --     | 10,771   | --        | --     | 1,811               | 122,404                   |
| Kentucky                                     | 592                | 10,671   | 37,400  | 9,864  | --     | 250      | 2,031     | --     | 157                 | 60,965                    |
| Mississippi                                  | 2,337              | 53,030   | 11,770  | --     | 5,787  | 5,869    | 859       | 484    | 2,028               | 82,164                    |
| Tennessee                                    | 7,603              | 66,363   | 14,502  | 5,710  | 582    | 2,488    | 5,873     | 7,060  | 7,057               | 117,238                   |
| Total  | 37,862             | 258,314  | 97,071  | 18,376 | 10,632 | 22,987   | 19,373    | 9,045  | 11,053              | 464,622                   |
| As a percentage of total interstate receipts | 7.8                | 53.3     | 20.0    | 3.8    | 2.2    | 4.7      | 4.0       | 1.9    | 2.3                 | 100.0                     |

a. Michigan, Nebraska, South Dakota and Wisconsin.  
Source: Stallings, J. L., Harris, J. M. and Sappington, C. Grain Movements Between Southern and Corn Belt States, Southern Cooperative Series, Bulletin No. 209, March 1976.

percent, or 3.9 million tons, of the area's exports in that year. This was 97 percent of outbound ORS waterborne grain movements, and over 70 percent of total waterborne grain movements.

The export market is anticipated to remain the dominant force in U.S. grain production. The importance of the export market to the United States and the Ohio River System hinterland is illustrated by the fact that the output of one out of every three acres in this country was exported, compared to one out of every five acres a decade ago. The quantity of corn, wheat, and soybeans exported from the United States increased 137 percent between 1969-76. The value of these exports increased between 1969-76 from \$2.2 billion to \$12.7 billion, expressed in current dollars.

#### B. Commodity Uses

Corn, wheat, and soybeans are the principal grains produced in the United States and constitute almost all waterborne grain traffic in the ORS. Other grains (such as barley and rye, oats, rice, and sorghum) move in relatively small quantities on the waterway.

##### B-1. Corn, Wheat and Soybeans

Corn is primarily a feed grain that is converted into pork, beef, poultry, and dairy products. Wheat, primarily a food grain, is converted into cereals or into flour for use by the baking industry in bread and other bakery products. The principal products from soybeans are oil and meal. As a major source of food fats and oils, soybeans are now the largest single source of vegetable fats and oil. Since 1950, soybean oil has exceeded cotton seed oil as the principal oil source in the manufacturing of both margarines and shortenings. The importance of soybean meal as a protein animal feed has increased rapidly, presently accounting for over half the total protein feed supply. Table 11 specifies in bushels and percentages the use of corn, wheat, and soybeans for feed, industrial purposes, seed, and exports in 1975.

Nearly 62 percent of the wheat produced in the United States was exported in 1975. Approximately 29 percent was used in food and for industrial purposes, primarily flour. Only 4 percent moved directly as feed, and 5 percent was used for seed. In the foreseeable future, it is probable that foreign demand will continue to provide the most important markets for U.S. wheat.

Most of the wheat consumed domestically is ground for edible flour. There are seven classes of wheat, as designated in the official grain standards of the U.S. Department of Agriculture: hard red spring wheat, soft red winter wheat, white winter wheat, hard red winter wheat, durum wheat, red durum wheat, and mixed wheat. Mixtures of wheats to obtain specific flour characteristics are common. The soft wheats produce flour used in baked goods, such as pies, pastry, and cakes. The hard wheats are used in making breads and rolls. Durum wheats are used in making pastas. Wheat is also used for making beer and, at times, is used in the production of starch and alcohol.

Approximately 62 percent of all corn consumed in the United States in 1975 was fed to livestock (Table 11). An additional 30 percent moved into the export market, primarily to Japan and to the European Common Market countries. Smaller quantities also moved into Eastern Europe and to the developing countries of the world. More than 90 percent of corn exported is to be used as feed grains.

Corn will continue to be the most important feed grain produced in the United States. Exports will continue to grow as incomes increase in Europe and in Asia. Food and seed use of corn will remain relatively small.

Food uses of corn include starch, corn syrup, corn sugar, alcohols, alcoholic beverages, and corn oil. Corn oil is used as an edible oil and also is used in soaps, belt dressings, core oils, paints and varnishes, and in the manufacture of rubber substitutes. Corn-derived confectionary flakes are used as an additive and conditioner in candy, cookies, and pastries. Corn syrup, derived from the germ of the corn, is a fast-growing sugar substitute in soft drinks and also is used in ice cream, candy, citrus imitations, cereal coating, and by the canning industry. Non-food uses of refined corn syrup (dextrose) include use as a base for the manufacture of lactic acid, sorbitol, and mannitol, which are industrial chemicals of growing usefulness. Corn starch is used predominantly by the paper industry and is used in powdered sugar, pie crusts, cake mixes, paint, wallboard, and ceiling tiles. Protein derived from corn is used for producing hard, tough, grease-resistant coatings and for formulating polishes and inks. Corn tassels are used for livestock and poultry feed, and corn stalks are used as cattle feed.

Soybeans are primarily crushed into oil and meal. In 1975, 58 percent of soybean production was crushed, and 37 percent was exported to foreign countries (Table 11). Soybeans are exported

Table 11. United States: Utilization of Corn, Wheat and Soybeans, 1975

| Use                     | Wheat               |         | Corn                |         | Soybeans            |         | All grains <sup>a</sup> |         |
|-------------------------|---------------------|---------|---------------------|---------|---------------------|---------|-------------------------|---------|
|                         | Millions of bushels | Percent | Millions of bushels | Percent | Millions of bushels | Percent | Millions of bushels     | Percent |
| Livestock feed          | 81.0                | 4.2     | 3,558.0             | 61.8    | 12.0                | 1.0     | 3,651.0                 | 39.9    |
| Food and industrial use | 559.0               | 29.3    | 491.0               | 8.5     | 865.1 <sup>b</sup>  | 58.2    | 1,915.1                 | 20.0    |
| Seed                    | 95.0                | 5.0     | c                   |         | 53.5                | 3.6     | 148.5 <sup>d</sup>      | 1.6     |
| Exports                 | 1,173.0             | 61.5    | 1,711.0             | 29.7    | 555.0               | 37.2    | 3,439.0                 | 37.6    |
| Total utilization       | 1,908.0             | 100.0   | 5,760.0             | 100.0   | 1,486.5             | 100.0   | 9,154.5 <sup>e</sup>    | 100.0   |

a. The total of corn, wheat and soybeans.

b. Beans crushed for food and feed purposes.

c. Included with food and industrial use.

d. Understated because corn for seed included with food and feed use.

e. May not add to total due to rounding.

Source: U.S. Department of Agriculture, Agricultural Statistics, 1977.

primarily to Common Market countries, Japan, and China. Less than 4 percent of the beans were used for seed, and less than 1 percent of raw beans were fed to livestock. It is expected that exports will remain strong, reflecting economic growth that is occurring in Europe and Japan.

Soybean oil is used almost exclusively as a food oil in the production of shortening, margarine, and cooking and salad oils. However, non-food uses, including uses as a drying oil for linoleum, as paint and varnish, and as a mix with linseed oil, account for about 7 percent of consumption. Soybean oil is also used in core oils, soaps, lubricants, and rubber compounding. Epoxidized soybean oil is used in vinyl and alkyd resins as a plasticizer and to increase heat resistance. Soybean flour is used in bakery food products, and soy proteins are used in canned soups and as meat extenders.

In total, nearly 40 percent of the use of corn, wheat and soybeans is for feed. Thirty-eight percent is exported, and approximately 20 percent is used for food and industrial purposes. Less than 2 percent is replanted as seed (Table 11).

#### B-2. Minor Grains

Barley and rye, oats, rice, and sorghum are other grains that moved in the ORS between 1969-76, but in relatively small quantities. Table 12 presents the uses of these grains in the United States in 1975.

Barley has a high protein content but low gluten; therefore, it is adequate as animal feed but makes a poor breadstuff. The chief non-feed use of barley is as malt, which is barley that has been germinated and then dried. Malt is used for making beer and malt extracts. Barley is also consumed directly by humans as pearl barley and in breakfast foods.

Oats, although one of the most nutritious of grains, is used predominantly as an animal feed. Rolled oats and oatmeal are used as cereal food and for some bakery products, but the grain is not suitable as a breadstuff. Oat hulls are used for the production of furfural and other chemicals.

1. Furfural is a liquid aldehyde used as a solvent and in making phenolic resins and furan. Furan is used in the manufacture of nylon.

Table 12. United States: Utilization of Barley, Oats, Rice, Rye and Sorghum, 1975

| Use                     | Barley              |         | Oats                |         | Rice                |         | Rye                 |         | Sorghum             |         |
|-------------------------|---------------------|---------|---------------------|---------|---------------------|---------|---------------------|---------|---------------------|---------|
|                         | Millions of bushels | Percent | Millions of bushels | Percent | Millions of bushels | Percent | Millions of bushels | Percent | Millions of bushels | Percent |
| Livestock feed          | 182                 | 51.4    | 562                 | 85.0    | --                  | --      | 7.0                 | 36.6    | 502                 | 68.1    |
| Food and industrial use | 148                 | 41.8    | 85                  | 12.9    | 36.8                | 38.0    | 6.2                 | 32.5    | 6                   | 0.8     |
| Exports                 | 24                  | 6.8     | 14                  | 2.1     | 56.5                | 58.4    | 1.1                 | 5.8     | 229                 | 31.1    |
| Seed                    | a                   | --      | a                   | --      | 3.5                 | 3.6     | 4.8                 | 25.1    | a                   | --      |
| Total utilization       | 354                 | 100.0   | 661                 | 100.0   | 96.8                | 100.0   | 19.1                | 100.0   | 737                 | 100.0   |

a. Included with food and industrial use.  
Source: U.S. Department of Agriculture, Agricultural Statistics, 1978.



Rice is a cereal grass, and its predominant use is as direct food. The milling of rice leaves a by-product that is used as animal feed. Other by-product food uses of rice include flour, cereal, and puddings, and for the manufacture of starch and alcoholic beverages. Rice bran oil is used as a salad and cooking oil and in lubricants. Rice wax is used in polishes.

Rye is valued chiefly for the production of whiskey and alcohol and for feeding animals. Between 12 and 15 percent of the rye produced in the United States is used in distilled alcohols. When used for flour, rye is blended with wheat and other flours.

Sorghum is used almost exclusively as an animal feed. A limited amount is used as sorghum, or sorgo, syrup, which is high in mineral salts valuable as foods. The syrup contains sugars other than sucrose and can be used in some confectionery.

All five of these grains are used as seed. Rice, rye, and barley straw (the sunbleached and dry stalks of the plant) are tough and resilient straws, are used for packing, bedding, and in the production of strawboard.

#### C. Consumption Characteristics

The price of grain is determined by the interaction of derived demand and grain supply functions. As incomes, population, expected prices, and prices of competing and complementary goods change in the United States and in the world, the demand for meat, oil products, flour, and cereals changes. Grain is sold in an international market; therefore, the price and the movement of grain depends, in part, on world demand.

Grain prices also depend upon grain supply. Everything else being equal, increases in the supply of grain decrease price. The United States has had an historical comparative advantage in the production of grain. Although production abroad is increasing (e.g., Brazil is making inroads into world grain markets, especially soybeans), the United States will be in a favorable competitive production position for the remainder of this century.

Grain prices in local markets are based on prices quoted in the formal futures markets. Therefore, if the price for delivery in December is \$2.20/bushel for corn in the futures market, an elevator operator may offer 30 cents less, or \$1.90/bushel, to the local farmer. The extent to which the offer is less than the futures market price depends on the location of the local market

relative to markets in which the local elevator will be selling grain, local transportation costs, the supply of grain, storage capacities, and local demand. It is important to note that the futures market reflects expected prices in some future period, and the price in the local market reflects current supply and demand relationships.

C-1. Corn, Wheat, and  
Soybeans

As indicated above, corn is primarily consumed as feed, wheat is processed into flour, and soybeans are crushed into meal and oil. The consumption characteristics of these grains are determined by their end-uses and by the market conditions affecting their end-uses.

a. Feed Grain Consumption

Changes in the number of animal units fed from one year to the next are determined mainly by the change in the total supply of feed concentrates and by the relative levels of feed and livestock prices. Effective price levels are those that prevail when farmers are making decisions regarding the number of animal units to be fed during the crop year. Breeding for the fall pig crop takes place in the preceding spring, and breeding for the spring pig crop occurs in the preceding fall and winter. Hens fed during the crop year come mainly from chicks hatched the preceding spring. Thus, the number of animal units fed in the crop year, beginning in October, is determined mainly by the price levels prevailing during the corresponding calendar year.

A second factor influencing the number of animal units fed is the anticipated cost of feed grain. Obviously the higher the anticipated grain price, the higher the expected cost of the feed and the lower the profit expectations. These results are obvious

---

1. The feeding industry is very capital intensive, with a large demand for short-term borrowed money. The rise in interest rates that followed the Federal Reserve System's October 1979 credit-tightening actions impacted on the feeding industry markedly. One producer reported that his total dollar interest costs had risen to about \$45 dollars for each head of cattle, from about \$30 a head in the previous spring (Wall Street Journal, 5 December 1979, p. 38). Higher feed and interest costs significantly impact on the feeder's costs of putting a pound on one of his cattles. When the price for fed cattle is weak and the above conditions prevail, feedlots will be marginally profitable at best.

from the 1973-74 period when livestock numbers were reduced drastically as corn and soybean meal prices rose to record highs.

To some extent, grains can be substituted for one another in feeding. The controlling factors are the protein level and energy content (calories) that any one grain will provide relative to its price.

Corn is the major grain that is converted into feed because it has a relatively high feed value at a relatively low price. Sorghum has a relative feeding value ranging from 90 to 100 percent of the value of corn, depending upon the livestock species (Table 13).

In the foreseeable future, corn will be the major feed ingredient. Although sorghum is a near substitute for most species of livestock, it has a comparative disadvantage in terms of production. Most midwestern states produce corn rather than sorghum. Wheat can be substituted for corn, up to 50 percent in most grain rations. However, price differentials relative to its feed value prevent wheat from being used as feed. Given our existing feed and wheat programs, it is not likely that wheat will become a major feed grain by the year 2000. Oats and barley are poor substitutes, both in terms of the amount that can be included in the ration and in terms of their relative feeding value. In summary, corn is expected to be the major feed grain for the remainder of this century.

Grain fed livestock rations vary by species. For example, hogs and poultry must have large quantities of grain in their diets. On the other hand, the ruminant animals,<sup>1</sup> such as cattle and sheep, may have a high roughage ration or a high concentrate ration. Decisions by the farmer to feed grain to the ruminants are based on grain prices, roughage prices, and the price of beef and sheep. In general, during periods of inflated prices, or during a period of rising livestock prices and relatively cheap grain prices, grain, rather than high roughage diets, will be fed to the ruminants.

In addition to ration variation by species, grain fed to various livestock species varies by state or region, based on the relative prices of grains. The ration fed to the various livestock categories by both type of grain and by selected PSA states is shown in Table 14.

---

1. Even-toed hoofed mammals that chew the cud and have a complex 3- or 4-chambered stomach.

Table 13. Nutrient Value of Selected Feeds Compared to Corn for Livestock and Poultry

(Percent)

| Species | Wheat <sup>a</sup> | Sorghum <sup>b</sup>   | Oats <sup>c</sup> | Barley <sup>d</sup> |
|---------|--------------------|------------------------|-------------------|---------------------|
| Hogs    | 90-100             | 90-95                  | 65-75             | 85                  |
| Cattle  | 100-105            | 90-95                  | 85-90             | 95                  |
| Sheep   | 100-105            | 90-95                  | 85-90             | 95                  |
| Poultry | 100                | 20 or 100 <sup>e</sup> | 50-60             | 80 <sup>f</sup>     |

a. Substitutability for corn up to 50 percent of grain ration.

b. Substitutability for corn up to 100 percent of grain ration.

c. Substitutability for corn up to 35 percent of grain ration.

d. Substitutability for corn up to 50-75 percent of grain ration.

e. Maximum 20 percent of bird resistant sorghum; 100 percent on yellow sorghum.

f. Standard weight barley.

Source: Ohio State University, Department of Animal Science Nutrition Specialists.

Table 14. Ohio River Basin: Livestock Feed Rations by Grain Type and Selected Livestock Category, for Selected Primary Study Area States  
(Tons)

| State and ration                       | Livestock category |                |                  |                |             |                 |
|--|--------------------|----------------|------------------|----------------|-------------|-----------------|
|  | Milk cows          | Cattle on feed | Hens and pullets | Turkeys raised | Pigs raised | Sheep and lambs |
| <u>Illinois</u>                        |                    |                |                  |                |             |                 |
| Corn                                   | 1.7000             | 1.2300         | 0.0375           | 0.0360         | 0.4615      | 0.0650          |
| Soybeans <sup>a</sup>                  | 0.4250             | 0.0950         | 0.0070           | 0.0075         | 0.0550      | 0.0200          |
| Wheat                                  | b                  | 0.0600         | 0.0025           | 0.0020         | 0.0225      | b               |
| <u>Indiana</u>                         |                    |                |                  |                |             |                 |
| Corn                                   | 1.3050             | 1.1625         | 0.0330           | 0.0175         | 0.3890      | 0.0955          |
| Soybeans <sup>a</sup>                  | 0.4000             | 0.0948         | 0.0080           | 0.0068         | 0.0650      | 0.0053          |
| Wheat                                  | b                  | 0.0025         | b                | b              | 0.0075      | b               |
| <u>Kentucky</u>                        |                    |                |                  |                |             |                 |
| Corn                                   | 1.7640             | 1.5120         | 0.0330           | 0.0252         | 1.5120      | 0.0504          |
| Soybeans <sup>a</sup>                  | 0.3300             | 0.0660         | 0.0126           | 0.0055         | 0.0990      | 0.0044          |
| Wheat                                  | 0.2100             | 0.1800         | 0.0050           | 0.0030         | 0.1800      | 0.0060          |
| <u>Tennessee</u>                       |                    |                |                  |                |             |                 |
| Corn                                   | 1.5000             | 1.7565         | 0.0320           | b              | 0.4455      | b               |
| Soybeans <sup>a</sup>                  | 0.1425             | 0.0355         | 0.0070           | b              | 0.0495      | b               |
| Wheat                                  | 0.0100             | b              | b                | b              | 0.0010      | b               |
| a. Ration stated in soybean meal terms |                    |                |                  |                |             |                 |

a. Ration stated in soybean meal terms.  
b. No ration fed.

Source: Compiled by RRNA from interviews with academic sources.

In determining the amount of grain that will be consumed by animals, waste or loss must also be included. It is normally assumed that an additional 5 percent of the total ration will be lost in the manufacturing and feeding process.

The amount of grain consumed by livestock will depend on the growth in the livestock industry, livestock cycles, technological changes, and institutional characteristics. The annual production of pork and poultry has steadily increased since 1950 (Table 15). Hog production varies from year to year because of the hog cycle, and poultry production increases rather consistently from one year to the next.

The hog cycle is approximately four years in length; therefore, the hog farmer will increase hog production in response to expected price increases and subsequently decrease production for four years in anticipation of falling prices. Variations occur in the four-year cycle due to fluctuations in the size of the corn crop (corn prices) and the impact of the cattle cycle.

Cattle production has been increasing very rapidly and cyclically (Table 15). Beef is the predominant source of meat, accounting for 45 percent of the total meat production in 1977. The cycle in beef cattle numbers is more than twice as long as is the cycle in hogs. Again, farmers increase beef production whenever prices are expected to increase and decrease production whenever prices are expected to decline. These livestock production decisions, with reference to anticipated prices, are based more on psychological than economic reasoning.

There is presently a down-trend in the cycle. The cycle should bottom out in late 1979 or early 1980. This suggests that by 1990 and the year 2000, the cattle industry could exhibit two full cycles.

Veal and lamb are not important contributors to meat production in the United States. In 1977, the veal and lamb industries contributed only 2 percent to total meat production (Table 15). These downward trends will not change in the foreseeable future.

Major technological changes and institutional changes have occurred in the poultry industry with modest changes in the cattle and hog industries. Research has substantially increased the rate of gain in the poultry industry. This means that less grain is required to produce a pound of poultry, and birds currently move to

Table 15. United States: Meat Production by Species,  
Selected Years, 1950-77

(Millions of pounds)

| Year | Beef   | Veal  | Lamb and<br>mutton | Pork   | Poultry <sup>a</sup> | Total  |
|------|--------|-------|--------------------|--------|----------------------|--------|
| 1950 | 9,534  | 1,230 | 597                | 10,714 | N.A. <sup>b</sup>    |        |
| 1960 | 14,728 | 1,109 | 768                | 11,598 | 6,928                | 35,131 |
| 1965 | 18,699 | 1,020 | 651                | 11,142 | 9,556                | 41,068 |
| 1970 | 21,685 | 588   | 551                | 14,699 | 12,953               | 50,476 |
| 1975 | 23,976 | 873   | 410                | 11,779 | 13,975               | 51,011 |
| 1977 | 25,279 | 834   | 351                | 13,247 | 16,054               | 55,765 |

a. Live weight, poultry slaughtered under Federal inspection.

b. N.A. - not available.

Source: U.S. Department of Agriculture, Economic Research Service: Livestock and Meat Statistics. U.S. Department of Agriculture, Agricultural Statistics.

market in shorter periods of time than in the past. Poultry production has also moved into southern states because of the climatic advantages. This means that grain produced in the Midwest must be shipped into the South.

Some changes have also occurred in the beef and hog industries. Hogs and cattle, predominantly produced in the Midwest and West, are produced by independently owned farm firms. Large feedlots for cattle are growing in numbers, and large finishing operations are appearing in the hog industry. Vertical integration does not appear to be an important or growing institution in either of these industries.

Hogs and cattle are fattened in midwestern feedlots characterized by economies of scale, cheaper feed grains, adequate handling facilities, intensive management, and a ready market.

#### b. Grain Processing

Soybeans and wheat are processed into food and feed products. As previously indicated, soybeans have become the major source of protein feed for beef, hogs, and poultry. For example, in 1960, 8.8 million tons of soybean meal were fed to livestock. In 1977-78, the U.S. Department of Agriculture estimated that the domestic use of soybean meal had reached an all time high of 21.4 million tons. Substitutes for soybean meal protein include fish, palm, sunflower, peanut, and cottonseed meal. Soybeans will continue to be a very important source of protein for feed. As a result, the price of livestock and their products will have a direct bearing on the price of soybeans and their movements.

Soybean oil is also a very important product of processing. Ninety-three percent of the soybean oil produced in 1977 was consumed by the food industry; the non-food industry consumed the remaining 7 percent. This product is used in shortening, margarine, cooking and salad oils, paints and varnishes, resins and plastics, and other drying oil processes.

Since consumption of oil is increasing, changes in the demand factors, income, population, prices of competing goods and expected prices will have a direct impact on the price of soybeans. For the remainder of this century, soybean oil will be an important product. If economic growth continues, prices of soybeans can be expected to increase, resulting in increased production of soybeans relative to other grains.



Wheat, a food grain, is primarily processed into flour and cereal products. The per capita consumption of flour and cereal is relatively stable, averaging 107 pounds for flour and 2.9 pounds for cereal in 1977. Increases in demand for these products are influenced by population growth and changes in prices of competing products. Flour will continue to be an important ingredient in our diets, but wheat prices will be equally influenced by foreign demand for wheat. It must be kept in mind that more than 60 percent of the U.S. wheat has been exported in recent years.

c. Grains for Seed

The volume of grain used for seed is unimportant relative to other uses (Table 11). Many scientific breakthroughs relating to seed occurred in the first half of this century. Because of research and extension education efforts, most farmers are planting hybrid seeds. An important change in the last 15 years appears to be the increase in seeding rates for corn in the southern states. Since the utilization of grain for seed is a minor use of grain, changes in seeding rates will have only a minor impact on the price or movement of grain.

C-2. Minor Grains

The use of barley and rye, oats, rice, and sorghum as feed grains is limited relative to the use of corn, wheat, and soybeans. As stated earlier, sorghum is a near substitute for corn in terms of its relative feeding value. However, it has a comparative disadvantage because of the more abundant supply of corn. Oats and barley have considerably lower relative feeding value and can be substituted for corn up to 35 percent, between 50-75 percent of grain rations.

Price and demand for barley and rye are related to the brewing industry as well as to the livestock and food industries. Demand for rice is heavily influenced by the export market.

D. Existing Aggregate Demands

Between 1969-76 grain consumption in the PSAs averaged about 23 million tons annually. Much of the grain produced in the PSAs was consumed by the export market, but the majority was consumed domestically in the Northeast and in areas in the Southeast exterior to the ORS hinterland. The export market has been and is expected to remain a significant force in ORS hinterland grain

production and the dominant force in the waterborne movement of grain. The export market at the Gulf Coast ports of New Orleans and Baton Rouge consumed about 90 percent of outbound waterborne shipments of grain from the PSAs. In 1976, the New Orleans-Baton Rouge export market for ORS waterborne grain accounted for over 15 percent of PSA production.<sup>1</sup> Grain produced in the PSAs and destined for export is also moved by truck and rail.

Between 1969-76, waterborne grain flows from the ORS to the Baton Rouge and New Orleans ports accounted for somewhat more than 5 percent of all grain exported from the United States. The volume and value of U.S. agricultural exports increased dramatically. Historical data show that the U.S. share of world grain trade increased from about 36 percent in the 1960-62 period to about 50 percent in the 1975-77 period. The developed countries consumed the largest share of U.S. grain exports, but in the present decade, the developing countries have increased their U.S. grain imports more rapidly than the developed countries.

#### D-1. Corn, Wheat, and Soybeans

Consumption of corn, wheat, and soybeans in the PSAs during 1969-76 fluctuated between 22.0 million tons and 24.7 million tons. However, in general consumption decreased during the period. In the ORS hinterland, as a whole, consumption was concentrated in 12 of the 19 PSAs, mostly in the southeastern area of the hinterland. BEAs 54 (Louisville), 44 (Atlanta), 60 (Indianapolis), 62 (Cincinnati), and 63 (Dayton), major producing PSAs, accounted for a large percentage of ORS hinterland grain consumption (Table 16). These BEAs were and are expected to be significant producers of meat, poultry, and food and dairy products for northeastern and southeastern U.S. markets. Corn was the predominant feed grain, followed by soybeans and wheat.

##### a. Livestock Consumption

Livestock is the major consumer of grain in the United States and in the area served by the ORS. Between 1969-76, on the average, livestock accounted for 75 percent of the corn, wheat, and soybeans consumed in the PSAs (Table 17). Livestock consumption was the largest single end-use of grain in most PSAs. As shown in

---

1. The amount of ORS hinterland grain destined for export through other coastal ports and the Great Lakes is unknown.

Table 16. Ohio River Basin: Consumption of Grains,<sup>a</sup> by BEAs or BEA Segments,<sup>b</sup> 1969-76  
(Thousands of tons unless otherwise specified)

| BEA and BEA segment        | 1969     | 1970     | 1971     | 1972     | 1973     | 1974     | 1975     | 1976     | Average annual<br>percentage change,<br>1969-76 |
|----------------------------|----------|----------|----------|----------|----------|----------|----------|----------|---|
| <b>Primary Study Areas</b> | 23,459.3 | 24,706.7 | 23,906.1 | 23,215.7 | 23,315.5 | 22,287.7 | 21,950.6 | 22,081.5 | (0.86)  |
| BEA 44: Atlanta, GA        | 1,667.8  | 1,673.4  | 1,621.7  | 1,625.3  | 1,544.0  | 1,559.9  | 1,532.4  | 1,577.8  | (0.79)  |
| BEA 45: Birmingham, AL     | 1,295.8  | 1,311.7  | 1,319.6  | 1,323.8  | 1,258.5  | 1,214.8  | 1,218.8  | 1,272.9  | (0.25)  |
| BEA 46: Memphis, TN        | 385.4    | 385.1    | 433.8    | 368.7    | 370.0    | 386.4    | 373.3    | 310.9    | (3.02)  |
| BEA 47: Huntsville, AL     | 1,911.4  | 1,992.1  | 2,038.1  | 2,054.8  | 2,003.9  | 2,000.8  | 2,050.2  | 2,059.8  | 1.07  |
| BEA 48: Chattanooga, TN    | 1,840.1  | 1,861.6  | 1,915.5  | 1,909.5  | 1,849.3  | 1,813.5  | 1,797.7  | 1,823.0  | (0.13)  |
| BEA 49: Nashville, TN      | 2,601.3  | 2,781.2  | 2,632.8  | 2,502.7  | 2,519.5  | 2,353.2  | 2,404.6  | 2,270.6  | (1.92)  |
| BEA 50: Knoxville, TN      | 342.0    | 338.6    | 357.2    | 371.6    | 334.6    | 329.5    | 343.0    | 326.7    | (0.65)  |
| BEA 52: Huntington, WV     | 320.3    | 326.2    | 309.6    | 285.1    | 308.0    | 266.0    | 271.6    | 256.2    | (3.14)  |
| BEA 53: Lexington, KY      | 1,230.4  | 1,437.6  | 1,278.0  | 1,188.1  | 1,196.8  | 1,168.4  | 1,198.3  | 1,177.8  | (0.62)  |
| BEA 54: Louisville, KY     | 1,910.6  | 2,071.7  | 1,892.4  | 1,837.2  | 1,865.4  | 1,783.8  | 1,752.9  | 1,778.6  | (1.02)  |
| BEA 55: Evansville, IN     | 2,782.1  | 3,054.8  | 2,828.4  | 2,744.5  | 2,740.2  | 2,617.1  | 2,472.8  | 2,550.5  | (1.23)  |
| BEA 56: Terre Haute, IN    | 100.8    | 112.6    | 103.7    | 88.3     | 92.4     | 88.6     | 73.6     | 83.4     | (2.67)  |
| BEA 60: Indianapolis, IN   | 1,804.2  | 1,893.0  | 1,845.3  | 1,784.3  | 1,791.2  | 1,763.4  | 1,639.3  | 1,760.8  | (0.35)  |
| BEA 61: Anderson, IN       | 189.3    | 188.3    | 193.1    | 161.8    | 178.0    | 167.9    | 164.7    | 164.8    | (1.96)  |
| BEA 62: Cincinnati, OH     | 1,298.2  | 1,374.4  | 1,325.4  | 1,276.3  | 1,399.6  | 1,187.9  | 1,168.7  | 1,202.3  | (1.09)  |
| BEA 63: Dayton, OH         | 1,645.8  | 1,678.1  | 1,683.2  | 1,669.3  | 1,758.0  | 1,692.5  | 1,615.0  | 1,602.7  | (0.38)  |
| BEA 64: Columbus, OH       | 638.9    | 650.4    | 644.5    | 609.8    | 695.7    | 559.8    | 561.1    | 539.1    | (2.40)  |
| BEA 114: St. Louis, MO     | 204.1    | 214.2    | 225.9    | 217.4    | 218.0    | 208.4    | 205.2    | 205.2    | 0.08  |
| BEA 115: Paducah, KY       | 1,290.9  | 1,361.7  | 1,258.0  | 1,197.2  | 1,192.6  | 1,125.8  | 1,107.4  | 1,118.3  | (2.03)  |

Note: Individual items may not add to total due to rounding. Data assembled on a county level and aggregated into BEAs and BEA segments.

a. Total consumption of corn, wheat and soybeans. Corn is corn for grain. Wheat is all wheat. Soybeans are soybeans for beans. Consumption of grains represents the addition of the consumption of corn, wheat and soybeans by livestock, seed and processing.

b. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements. Source: Livestock consumption was estimated by taking the number of livestock by county for 11 categories of livestock (milk cows, cattle on feed, other cattle, hogs and pigs, sheep and lambs, hens and pullets, other chickens, broilers, turkeys, and horses and mules) and multiplying by an annual ration provided by the U.S. Department of Agriculture Crop Reporting Services for each grain (corn, wheat and soya) for each of the eight states (Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio and Tennessee). The rations were assumed to remain constant

(Continued)

Table 16. (Continued)

over the eight-year period. The livestock numbers were taken, to the extent possible, from data provided annually by the U.S. Department of Agriculture Crop Reporting Services for each of the eight states. Where only state totals were available, these were distributed on a county level based on the county distribution of the 11 livestock categories as provided by the U.S. Department of Agriculture, Census of Agriculture, 1974. Consumption of grains by processors was estimated by utilizing lists of grain processors by type of grain, capacity, and city and state location. These lists were provided by commodity experts. Processors were assigned to their appropriate county and BEA and BEA segment and assumed to be operating at capacity. Consumption of grains for seed was estimated by multiplying the BEA and BEA segment acres harvested for each grain by the crop seeding rate as provided for state and year in the U.S. Department of Agriculture, Agricultural Statistics (various years). A factor was included in the multiplication to reflect the difference between acres harvested and acres planted. Seeding rates were weighted for BEAs and BEA segments in two or more states, e.g., BEA 55.

Table 1. Summary of the results of the BEA surveys, 1969-76.  
 Estimated 1969-76  
 Thousands of eggs

| BEA and BEA member             | 1969    | 1970    | 1971    | 1972    | 1973    | 1974    | 1975    | 1976    |
|--------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| <b>BEA 40: Albany, GA</b>      |         |         |         |         |         |         |         |         |
| Livestock                      | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 |
| Processing                     | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 |
| Seed                           | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 |
| <b>BEA 41: Albany, GA</b>      |         |         |         |         |         |         |         |         |
| Livestock                      | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 |
| Processing                     | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 |
| Seed                           | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 |
| <b>BEA 42: Birmingham, AL</b>  |         |         |         |         |         |         |         |         |
| Livestock                      | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 |
| Processing                     | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 |
| Seed                           | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 |
| <b>BEA 43: Memphis, TN</b>     |         |         |         |         |         |         |         |         |
| Livestock                      | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 |
| Processing                     | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 |
| Seed                           | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 |
| <b>BEA 44: Birmingham, AL</b>  |         |         |         |         |         |         |         |         |
| Livestock                      | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 |
| Processing                     | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 |
| Seed                           | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 |
| <b>BEA 45: Chattanooga, TN</b> |         |         |         |         |         |         |         |         |
| Livestock                      | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 |
| Processing                     | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 |
| Seed                           | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 | 1,040.0 |

(Continued)

Table 17. (Continued)

| BEA and BEA segment     | 1969    | 1970    | 1971    | 1972    | 1973    | 1974    | 1975    | 1976    |
|-------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| BEA 49: Nashville, TN   | 2,601.2 | 2,781.3 | 2,632.8 | 2,502.6 | 2,519.5 | 2,353.2 | 2,404.6 | 2,270.6 |
| Livestock               | 2,427.9 | 2,608.0 | 2,456.2 | 2,321.9 | 2,339.2 | 2,164.5 | 2,214.5 | 2,078.4 |
| Processing              | 161.4   | 161.4   | 161.4   | 161.4   | 161.4   | 161.4   | 161.4   | 161.4   |
| Seed                    | 11.9    | 11.9    | 15.2    | 19.3    | 18.9    | 27.3    | 28.7    | 30.8    |
| BEA 50: Knoxville, TN   | 342.0   | 338.6   | 357.2   | 371.5   | 334.6   | 329.5   | 343.0   | 326.7   |
| Livestock               | 288.9   | 285.5   | 303.9   | 318.2   | 281.2   | 275.8   | 289.3   | 272.9   |
| Processing              | 52.4    | 52.4    | 52.4    | 52.4    | 52.4    | 52.4    | 52.4    | 52.4    |
| Seed                    | 0.7     | 0.7     | 0.9     | 0.9     | 1.0     | 1.3     | 1.3     | 1.4     |
| BEA 52: Huntington, WV  | 319.3   | 326.1   | 309.6   | 285.2   | 308.0   | 266.0   | 271.6   | 256.3   |
| Livestock               | 318.8   | 325.6   | 308.9   | 284.5   | 307.2   | 265.1   | 270.7   | 255.4   |
| Processing              | --      | --      | --      | --      | --      | --      | --      | --      |
| Seed                    | 0.5     | 0.5     | 0.7     | 0.7     | 0.8     | 0.9     | 0.9     | 0.9     |
| BEA 53: Lexington, KY   | 1,230.5 | 1,437.7 | 1,278.0 | 1,188.2 | 1,196.8 | 1,168.3 | 1,198.3 | 1,177.8 |
| Livestock               | 1,223.5 | 1,430.8 | 1,270.6 | 1,180.9 | 1,189.6 | 1,160.6 | 1,190.5 | 1,170.0 |
| Processing              | 5.6     | 5.6     | 5.6     | 5.6     | 5.6     | 5.6     | 5.6     | 5.6     |
| Seed                    | 1.4     | 1.3     | 1.8     | 1.7     | 1.6     | 2.1     | 2.2     | 2.2     |
| BEA 54: Louisville, KY  | 1,910.5 | 2,071.7 | 1,892.3 | 1,837.3 | 1,865.4 | 1,783.8 | 1,752.9 | 1,778.7 |
| Livestock               | 1,597.6 | 1,759.1 | 1,578.5 | 1,522.4 | 1,550.2 | 1,465.3 | 1,435.3 | 1,461.7 |
| Processing              | 306.0   | 306.0   | 306.0   | 306.0   | 306.0   | 306.0   | 306.0   | 306.0   |
| Seed                    | 6.9     | 6.6     | 7.8     | 8.9     | 9.2     | 12.5    | 11.6    | 11.0    |
| BEA 55: Evansville, IN  | 2,782.0 | 3,054.8 | 2,828.3 | 2,744.5 | 2,740.1 | 2,617.0 | 2,472.8 | 2,550.5 |
| Livestock               | 2,303.0 | 2,576.1 | 2,343.7 | 2,254.7 | 2,242.8 | 2,112.5 | 1,971.5 | 2,049.3 |
| Processing              | 436.5   | 436.5   | 436.5   | 436.5   | 436.5   | 436.5   | 436.5   | 436.5   |
| Seed                    | 42.5    | 42.2    | 48.1    | 53.3    | 60.8    | 68.0    | 64.8    | 64.7    |
| BEA 56: Terre Haute, IN | 100.7   | 112.5   | 103.6   | 88.3    | 92.3    | 88.7    | 73.7    | 83.4    |
| Livestock               | 96.3    | 108.5   | 99.3    | 84.0    | 87.8    | 83.2    | 68.4    | 78.0    |
| Processing              | --      | --      | --      | --      | --      | --      | --      | --      |
| Seed                    | 4.4     | 4.0     | 4.3     | 4.3     | 4.5     | 5.5     | 5.3     | 5.4     |

(Continued)

Table 17. (Continued)

| BEA and BEA segment      | 1969    | 1970    | 1971    | 1972    | 1973    | 1974    | 1975    | 1976    |
|--------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| BEA 60: Indianapolis, IN | 1,804.1 | 1,893.1 | 1,845.2 | 1,784.2 | 1,791.2 | 1,763.3 | 1,639.2 | 1,760.7 |
| Livestock                | 1,142.5 | 1,233.3 | 1,183.9 | 1,120.4 | 1,124.9 | 1,093.5 | 970.8   | 1,092.1 |
| Processing               | 632.4   | 632.4   | 632.4   | 632.4   | 632.4   | 632.4   | 632.4   | 632.4   |
| Seed                     | 29.2    | 27.4    | 28.9    | 31.4    | 33.9    | 37.4    | 36.0    | 36.2    |
| BEA 61: Anderson, IN     | 189.3   | 188.3   | 193.1   | 161.8   | 178.0   | 167.9   | 164.6   | 164.8   |
| Livestock                | 185.1   | 184.5   | 189.0   | 157.3   | 173.2   | 162.2   | 159.2   | 159.5   |
| Processing               | --      | --      | --      | --      | --      | --      | --      | --      |
| Seed                     | 4.2     | 3.8     | 4.1     | 4.5     | 4.8     | 5.7     | 5.4     | 5.3     |
| BEA 62: Cincinnati, OH   | 1,298.3 | 1,374.4 | 1,325.4 | 1,276.3 | 1,399.5 | 1,188.1 | 1,168.7 | 1,202.4 |
| Livestock                | 1,273.6 | 1,350.5 | 1,299.3 | 1,248.6 | 1,370.0 | 1,156.5 | 1,136.9 | 1,171.2 |
| Processing               | 7.7     | 7.7     | 7.7     | 7.7     | 7.7     | 7.7     | 7.7     | 7.7     |
| Seed                     | 17.0    | 16.2    | 18.4    | 20.0    | 21.8    | 23.9    | 24.1    | 23.5    |
| BEA 63: Dayton, OH       | 1,645.7 | 1,678.1 | 1,683.2 | 1,669.3 | 1,758.1 | 1,692.4 | 1,614.9 | 1,602.6 |
| Livestock                | 777.7   | 910.4   | 812.7   | 795.9   | 882.3   | 813.0   | 732.8   | 721.8   |
| Processing               | 841.2   | 841.2   | 841.2   | 841.2   | 841.2   | 841.2   | 841.2   | 841.2   |
| Seed                     | 26.8    | 26.5    | 29.3    | 32.2    | 34.6    | 38.2    | 40.9    | 39.6    |
| BEA 64: Columbus, OH     | 638.9   | 650.4   | 644.5   | 609.8   | 695.6   | 559.8   | 561.1   | 539.0   |
| Livestock                | 568.3   | 579.4   | 571.6   | 534.7   | 619.3   | 479.7   | 478.9   | 457.6   |
| Processing               | 45.9    | 45.9    | 45.9    | 45.9    | 45.9    | 45.9    | 45.9    | 45.9    |
| Seed                     | 24.7    | 25.1    | 27.0    | 29.2    | 30.4    | 34.2    | 36.3    | 35.5    |
| BEA 114: St. Louis, MO   | 204.1   | 214.3   | 225.9   | 217.5   | 218.0   | 208.5   | 205.2   | 205.2   |
| Livestock                | 194.2   | 206.7   | 216.7   | 206.7   | 206.5   | 196.8   | 193.8   | 192.8   |
| Processing               | --      | --      | --      | --      | --      | --      | --      | --      |
| Seed                     | 9.9     | 7.6     | 9.2     | 10.8    | 11.5    | 11.7    | 11.4    | 12.4    |
| BEA 115: Paducah, KY     | 1,290.9 | 1,361.7 | 1,258.1 | 1,197.2 | 1,192.6 | 1,125.7 | 1,107.4 | 1,118.3 |
| Livestock                | 800.7   | 870.7   | 764.5   | 700.9   | 696.0   | 627.0   | 601.1   | 619.0   |
| Processing               | 480.0   | 480.0   | 480.0   | 480.0   | 480.0   | 480.0   | 480.0   | 480.0   |
| Seed                     | 10.2    | 11.0    | 13.6    | 16.3    | 16.6    | 18.7    | 26.3    | 19.3    |

(Continued)

Table 17. (Continued)

Note: Individual items may not add to total due to rounding. Data assembled on a county level and aggregated into BEAs and BEA segments.

- a. Total consumption of corn, wheat and soybeans only. Corn is corn for grain. Wheat is all wheat. Soybeans are soybeans for beans.
- b. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

Source: Livestock consumption was estimated by taking the number of livestock by county for 11 categories of livestock (milk cows, beef cows, cattle on feed, other cattle, hogs and pigs, sheep and lambs, hens and pullets, other chickens, broilers, turkeys, and horses and mules). Each category was multiplied by an annual ration provided by the U.S. Department of Agriculture Crop Reporting Services for each grain (corn, wheat and soya) for each of the states (Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio and Tennessee). The rations were assumed to remain constant over the eight-year period. The livestock numbers were taken, to the extent possible, from data provided annually by the U.S. Department of Agriculture Crop Reporting Services for each of the eight states. Where only state totals were available, these were distributed on a county level based on the county distribution of the 11 categories as provided by the U.S. Department of Agriculture, Census of Agriculture, 1974. Consumption of grains by processors was estimated by utilizing lists of grain processors by type of grain, capacity, and city and state location. These lists were provided by commodity experts. Processors were assigned to their appropriate county and BEA segment and assumed to be operating at capacity. Consumption of grains for seed was estimated by multiplying the BEA and BEA segment acres harvested for each grain by the crop seeding rate as provided for state and year in the U.S. Department of Agriculture, Agricultural Statistics (various years). A factor was included in the multiplication to reflect the difference between acres harvested and acres planted. Seeding rates were weighted for BEAs and BEA segments in two or more states, e.g., BEA 55.



Table 18, in only a few BEAs [47 (Huntsville), 48 (Chattanooga) and 63 (Dayton)] did grain consumption by other end uses equal or exceed livestock consumption.

However, livestock consumption of corn, wheat, and soybeans in the PSAs decreased by more than 9 percent between 1969-76, declining from 17.8 million tons in 1969 to 16.3 million tons in 1976.

Of the 11 categories of livestock, the four poultry classes are predominant in the southeastern PSAs. Hogs and cattle raised in these PSAs generally are sent to the Midwest (Illinois and Indiana) to feedlots to be "fed-out" and marketed. This pattern exists because of the in-place administrative, management, and distribution structure for livestock production in the Midwest, as well as the distribution of grain surpluses.

#### b. Processing Consumption

As presented in Table 17, commercial processing accounted for between 22 and 25 percent of grain consumption in the ORS hinterland during 1969-76. Some PSAs had no processing capacity: namely, BEAs 52 (Huntington), 56 (Terre Haute), 61 (Anderson), and 114 (St. Louis). Eight of the 19 PSAs accounted for more than 90 percent of hinterland grain consumption by processors. In each of the eight BEAs [44 (Atlanta), 47 (Huntsville), 48 (Chattanooga), 54 (Louisville), 55 (Evansville), 60 (Indianapolis), 63 (Dayton), 115 (Paducah)] there was and is a soybean processor.

For the ORS hinterland, in general, soybean processors represented about 64 percent of total processing capacity between 1969-76. Corn processing capacity, both wet and dry-milling, accounted for 24 percent of ORS hinterland grain processing capacity, and wheat processing capacity accounted for approximately 12 percent.

Processing capacity is concentrated largely in the southeastern PSAs. In these areas, processors are frequently part of integrated poultry farms (i.e., the processor prepares the feed and owns and markets the birds).

#### c. Seed Consumption

Consumption of grain for seed is a minor end-use and accounted for less than 1 percent of total grain consumption in 1970 to more than 1.5 percent in 1976. Between 1969-76, ORS hinterland seed

consumption increased 56 percent from 218,400 tons to 341,600 tons. This increase is directly related to the increases in grain production in the PSAs. By PSA, there is some variation in the percentage share that seed consumption represents of total grain consumption, depending upon the presence and capacity of processors and the concentration of livestock production.

In general, grain consumption for seed was greater and grew at a faster rate in those PSAs in which ORS hinterland grain production was significant and growing. Examples include BEAs 49 (Nashville), 55 (Evansville), and 60 (Indianapolis).

#### D-2. Minor Grains

U.S. aggregate demand for barley and rye, oats, rice, and sorghum was presented earlier in this report under commodity uses. As discussed, the major end-use for all of these minor grains, except rice, is animal feed. Barley and rye are also used in the production of distilled spirits and beer. Most rice is consumed as food.

Export demand between 1969-75 for these five grains, as a percent of total U.S. supply (beginning stocks + production + imports), averaged as follows:

|         |                   |
|---------|-------------------|
| Barley  | 8.6 percent       |
| Oats    | 1.8               |
| Rice    | 51.0              |
| Rye     | 12.4 <sup>1</sup> |
| Sorghum | 20.2 <sup>1</sup> |

In general, these minor grains are consumed on the farms where they are produced. For the eight states in the ORS hinterland that have counties which comprise PSAs, minor grain use on farms where produced, as a percent of production, in 1976 was as follows:

|         |                   |
|---------|-------------------|
| Barley  | 61.9 percent      |
| Oats    | 54.8              |
| Rice    | 0.5               |
| Rye     | 38.0 <sup>2</sup> |
| Sorghum | 61.6 <sup>2</sup> |

---

1. U.S. Department of Agriculture, Agricultural Statistics, 1977 ed. (Washington, D.C.: USDA, 1978).

2. Ibid.

In 1970, all rye that was produced in Illinois, Ohio, and Indiana, and that was not consumed on the farm where produced or within the state, was destined for Kentucky. Almost all barley went to Corn Belt states other than Illinois, Ohio, and Indiana. Sorghum was destined for Alabama, Georgia, and Louisiana. About 45 percent of oat shipments was destined for other Corn Belt states, with the Northwest and the South each receiving an additional 20 percent.

#### E. Forecasting Procedures and Assumptions

Regional-level projections of livestock production (grain consumption) that correspond to the Ohio River System hinterland do not exist. Livestock production projections for the states that contain PSAs of the ORS hinterland exist but were found to be inadequate in that the time frames, assumptions, and base data did not correspond.

National agriculture projections of the USDA were selected as the state-level base for projections of grain consumption in the PSAs. These projections were developed by a computer model that simulates the farm production sector with linkages to the natural resource base, the food consumption sector, the general economy, farm inputs, and world trade.

##### E-1. U.S. Department of Agriculture: National Interregional Agricultural Projections Systems

The USDA National Interregional Agricultural Projections Systems (NIRAP) provides nationally and interregionally consistent projections under a wide range of assumptions. The model starts from the national level and disaggregates national projections to regional and state levels by individual commodities.<sup>2</sup> The presence and interaction of several factors (such as historical commodity production and utilization, cropland availability, and anticipated future food prices) are considered in the model.

---

1. J.L. Stalling, et al., Grain Movements Between Southern and Corn Belt States, Southern Cooperative Series, No. 209 (Auburn, AL: Alabama Agricultural Experiment Station, 1976).

2. National projections are disaggregated to state levels based on a varying distribution of state shares of national production over time.

NIRAP system scenarios are precise statements of assumptions and/or projections required to describe the "environment" of the agricultural economy. The baseline scenario was chosen with variables that constitute boundaries of assumed growth ranges for major attributes, such as income, that cause non-price related shifts in the quantity of major commodities and aggregate output demanded and supplied. The model allows for adjustments in response coefficients and elasticities, where logic and consistency require, to allow for changes in producers' and consumers' responses to price.

The attributes quantified in the scenario bounds are divided into demand and supply shift attributes:

Demand Attributes

Domestic population growth

Domestic income growth

Taste and preferences  
(meat substitutability)

Agricultural trade

Supply Attributes

Public expenditures  
for research and  
extension

Environmental controls

Inflation

Climate

The baseline can be interpreted as the midpoint of possible combinations of attribute values falling in a range considered manageable.

The projected demand and supply attributes for the baseline food and agricultural scenario for 1985, 1990, and 2000 for the United States are presented in Table 18.

State and commodity level projections are generated by USDA for the years 1985, 1990, and 2000, providing a consistent and comparative set of projections. These are generally regarded as the best set of state and commodity level projections available.

USDA's state level livestock production projections for the years 1985, 1990, and 2000 are in millions of pounds for cattle, hogs, sheep, chickens, broilers, and turkeys; in millions of eggs for hens and pullets; and in pounds of milk for dairy cows. Pounds of livestock, number of eggs and pounds of milk were converted into livestock numbers for the period 1985, 1990, and 2000. State level

Table 18. Grains: Projected Demand and Supply Attributes, Baseline Scenario, 1985, 1990 and 2000, United States

| Attribute and level  | Actual 1975-77     | 1985     | 1990     | 2000     |
|--|--------------------|----------|----------|----------|
| <b>Demand</b>  |                    |          |          |          |
| <u>Population growth (millions)</u><br>Series II   | 215.2              | 232.9    | 242.3    | 260.4    |
| <u>Economic growth (GNP) (billions 1972 dollars)</u><br>Moderate (3.0 percent/year)                                      | 1,271.4            | 1,594.4  | 1,848.4  | 2,484.0  |
| <u>Economic growth (per capita disposable income)</u><br>(1972 dollars)  |                    |          |          |          |
| Series II population - moderate GNP  | 4,148.0            | 4,876.0  | 5,497.0  | 7,005.0  |
| <u>Tastes and preferences (percent meat substitutes)</u>   | 2-5                | 2-5      | 2-5      | 2-5      |
| <u>Agricultural trade</u>  | High               | Moderate | Moderate | Moderate |
| <b>Supply</b>  |                    |          |          |          |
| <u>Public expenditures for agricultural research and extension program (millions 1972 dollars)</u><br>3.0 percent growth | 795.0 <sup>a</sup> | 1,155.8  | 1,339.0  | 1,800.7  |
| <u>Inflation index (1972 = 100)</u><br>Moderate (5.0 percent year)   | 116.0              | 171.0    | 218.3    | 355.6    |
| <u>Climate (Index)<sup>b</sup></u><br>Neutral  | 97.0               | 101.6    | 101.6    | 101.6    |

a. 1973-75 average.

b. The Stallings' weather index. This index is designed to measure the direct influence of weather and the indirect influence of insects and disease on agricultural output. Variables such as crop variety, soil and certain cultural practices are held constant. The index is computed as the ratio of the actual to the computed yields of a linear regression. An index value of 100 is normal weather. Adverse weather would yield values less than 100 and better than normal weather would yield values greater than 100.

Source: Leroy Quance, et. al., Adjustment Potential in U.S. Agriculture, Volume I: Scenario, Production, Price and Income Projections to 1985, 1990 and 2000, U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service, Economic Projections and Analytical Systems, National Economic Analysis Division, Washington, D.C.: n.d.

livestock numbers for 1980 were estimated by interpolating backwards an annual growth trend line of the 1974-76 base to 1985.

E-2. Disaggregation of State Level  
Data to BEA Level

For the period 1969-76, the number of each of the 11 different categories of livestock produced by PSA was identified and divided by the state total to derive a percentage share produced in each PSA. Linear regression analysis in conjunction with expert judgment was used to allocate percentage shares for each PSA for the projection period to the year 2000. These projected percentage shares were multiplied by the USDA projected state livestock numbers, by category. Thus, USDA projections of livestock production were allocated to each PSA.

Projections of livestock production to 2040 were estimated by determining, for each PSA, the difference between a livestock production average of 1974-76 and 2000 and dividing this difference by two and allocating this to 2040. Thus, the rate of increase in livestock numbers between 2000 and 2040 is one-half the increase expected between 1974-76 and 2000.

Consumption of corn, wheat, and soybeans by livestock category was estimated by multiplying feed rations, as specified by USDA, times livestock numbers for each PSA for each projection year. Corn, wheat, and soybean consumption for each species and for each PSA was multiplied by 1.05 to reflect the 5 percent grain loss in the handling process.

Grain processing capacity, as estimated for 1969-76, was assumed constant for the period 1980 to 2040 except for known expansion [BEA 47 (Huntsville)]. Plans for expansion and new entries are basically unknown, and companies are unwilling to supply additional information.

For the period 1980 to 2040, grain production for each PSA was divided by yield per acre, as estimated by USDA, to estimate acres harvested. The seeding rates per crop and per state, as specified by USDA, were multiplied by the estimated acres harvested for each PSA. In this way, seed use for planting for each PSA was estimated for the years 1980 to 2040.

For each of the three principal crops, the projected consumption by each of the three end-uses was summed to estimate total

consumption by crop by PSA. The total consumption of each of the three crops was summed to estimate total grain consumption for the years 1980 to 2040 for each PSA.

#### F. Probable Future Demands

The projections for grain consumption in the PSAs suggest gradual but steady increases in total grain consumption between 1976 and 2000, 0.54 percent annually, and between 2000 and 2040, 0.19 percent annually (Table 19). With the exception of BEAs 61 (Anderson), grain consumption by livestock, processing, and seed is to increase in all PSAs between 1976 and 2000. BEA 56 (Terre Haute) is expected to experience a notable increase. BEA 56's increase will be from increased consumption by livestock.

Corn will remain the predominant grain consumed in the ORS hinterland, representing, on the average, 60 percent of total grain consumption. Soybeans will account for about 35 percent of total grain consumed, and wheat for about 5 percent. Livestock feed will remain the major end-use of grain in the PSAs, followed by processing and seed.

In the ORS hinterland, as a whole, consumption is expected to remain concentrated in 12 of the 19 PSAs. The ORS hinterland is expected to remain a significant producer of meat, poultry, and food and dairy products for the northeastern and southeastern markets of the United States.

The aggregate demand for ORS hinterland grain represented by the export market in the future is expected to remain significant. However, the domestic market is expected to remain the major consumer of ORS hinterland grain. Given income and population increases, the demand for food in the developing countries is expected to almost quadruple as these countries' share of world agricultural imports increases from 15.3 percent in 1970 to 39.4 percent in the year 2000. U.S. agricultural exports to the developing countries are expected to increase substantially under assumed income and population increase. However, consumption by developed countries of U.S. grain, and ORS hinterland grain, is expected to dominate the export market.

---

1. U.S. Department of Agriculture, Economic Research Service, World Economic Conditions in Relation to Agricultural Trade, WEC-13 (Washington, D.C.: USDA, p. 49).

Table 19. Ohio River Basin: Consumption of Grain<sup>a</sup>, by BEAs or BEA Segments<sup>b</sup>, Estimated 1976 and Projected 1980-2040, Selected Years  
(Thousands of tons unless otherwise specified)

| BEA and BEA segment      | Estimated<br>1976 | Projected |          |          |          | Average annual<br>percentage change |           |        |
|--------------------------|-------------------|-----------|----------|----------|----------|-------------------------------------|-----------|--------|
|                          |                   | 1980      | 1990     | 2000     | 2040     | 1974-76                             | 2000-2040 |        |
| Primary Study Areas      |                   |           |          |          |          |                                     |           |        |
| BEA 44: Atlanta, GA      | 22,081.5          | 22,352.2  | 23,323.4 | 25,139.0 | 26,104.0 | 27,102.8                            | 0.54      | 0.19   |
| BEA 45: Birmingham, AL   | 1,577.8           | 1,558.6   | 1,666.5  | 1,789.8  | 1,876.0  | 1,968.2                             | 0.53      | 0.24   |
| BEA 46: Memphis, TN      | 1,272.9           | 1,234.0   | 1,305.0  | 1,521.1  | 1,600.9  | 1,686.8                             | 0.74      | 0.26   |
| BEA 47: Huntsville, AL   | 310.9             | 353.1     | 389.0    | 427.8    | 445.9    | 463.8                               | 1.34      | 0.20   |
| BEA 48: Chattanooga, TN  | 2,059.8           | 2,062.9   | 2,201.7  | 2,351.2  | 2,425.0  | 2,500.3                             | 0.55      | 0.15   |
| BEA 49: Nashville, TN    | 1,823.0           | 1,812.4   | 1,917.2  | 1,985.1  | 2,027.7  | 2,070.9                             | 0.36      | 0.11   |
| BEA 50: Knoxville, TN    | 2,270.6           | 2,453.3   | 2,623.3  | 2,940.0  | 3,075.0  | 3,215.1                             | 1.08      | 0.22   |
| BEA 51: Lexington, KY    | 326.7             | 339.5     | 354.7    | 372.1    | 393.3    | 414.2                               | 0.54      | 0.27   |
| BEA 52: Huntington, WV   | 256.2             | 276.7     | 268.7    | 297.7    | 284.2    | 284.5                               | 0.63      | (0.11) |
| BEA 53: Louisville, KY   | 1,177.8           | 1,233.0   | 1,291.6  | 1,415.6  | 1,512.1  | 1,609.0                             | 0.77      | 0.32   |
| BEA 54: Evansville, IN   | 1,778.6           | 1,747.3   | 1,818.1  | 1,955.7  | 2,063.8  | 2,173.4                             | 0.40      | 0.26   |
| BEA 55: Terre Haute, IN  | 2,550.5           | 2,428.6   | 2,576.3  | 2,873.2  | 3,037.2  | 3,206.4                             | 0.50      | 0.27   |
| BEA 56: Indianapolis, IN | 83.4              | 144.5     | 148.7    | 159.3    | 164.6    | 169.9                               | 2.73      | 0.16   |
| BEA 60: Anderson, IN     | 1,760.8           | 1,776.9   | 1,829.1  | 1,926.2  | 1,977.9  | 2,032.9                             | 0.37      | 0.13   |
| BEA 61: Cincinnati, OH   | 164.8             | 156.3     | 153.5    | 156.1    | 153.8    | 150.1                               | (0.23)    | (0.10) |
| BEA 62: Dayton, OH       | 1,202.3           | 1,234.4   | 1,239.7  | 1,356.9  | 1,401.1  | 1,447.2                             | 0.13      | 0.16   |
| BEA 63: Columbus, OH     | 1,602.7           | 1,719.6   | 1,674.5  | 1,671.3  | 1,670.4  | 1,672.0                             | 0.17      | 0.00   |
| BEA 64: St. Louis, MO    | 539.1             | 595.7     | 569.6    | 569.6    | 570.3    | 572.5                               | 0.23      | 0.01   |
| BEA 114: Paducah, KY     | 205.3             | 194.4     | 206.1    | 228.9    | 237.0    | 245.4                               | 0.45      | 0.17   |
| BEA 115:                 | 1,118.3           | 1,031.0   | 1,090.1  | 1,159.4  | 1,187.8  | 1,220.2                             | 0.15      | 0.13   |

Note: Individual items may not add to total due to rounding. Data assembled on a county level and assembled into BEAs or BEA segments.

a. Total consumption of corn, wheat and soybeans only. Corn is corn for grain. Wheat is all wheat. Soybeans are soybeans for beans. Consumption of grain represents the addition of the consumption of corn, wheat and soybeans by livestock, processing and seed.

b. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.  
Source: U.S. Department of Agriculture, Economic Research Service, USDA National-Interregional Agricultural Projections (NIRAP) System, July 1978.

This source provides state level projections of livestock production, by livestock category, to 2000. Livestock numbers raised by each of the states of Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio and Tennessee were averaged for 1974, 1975 and 1976 and represent base year livestock production. The base year level was subtracted from the 2000 projections. This difference was divided by two and reported as 2040. The difference between 2000 and 2040 was equally divided among the remaining years in ten year intervals. For each BEA and BEA segment, the percentage of the respective states' total livestock production (1969-1976) was estimated and was projected into the future using trend analysis, in conjunction with expert judgement. The percent of the state's total livestock production allocated to each BEA and BEA segment by period (1980 to 2040) was multiplied by the state totals to estimate livestock production by BEA and BEA segment. Livestock numbers were multiplied by the corn, wheat and soybean ratio fed by category by state. Acres harvested were multiplied by seeding rates by state to estimate grain consumption by seed. Processing capacity was assumed to remain constant from 1976 with the exception of known expansions and new construction.



Although the export market will remain a dominant force in ORS hinterland aggregate grain demand, the ORS hinterland will satisfy only between 5 and 10 percent of total export demand for U.S. grains.

### III. COMMODITY RESOURCES INVENTORY

Projections of future grain production in the PSAs generally have been based on assumptions about the future that underlie analyses and projections of the U.S. Department of Agriculture. As the premier agricultural research entity in the United States, USDA has resources and experience that could not be duplicated by this study.

Production of grains in the PSAs increased markedly between 1969-76, from 16.0 million tons to 25.6 million tons. Production increased most rapidly in those PSAs in the southeastern portion of the ORS hinterland. However, the largest producing PSAs were those in the States of Indiana, Illinois, and Ohio. Production of grains in the PSAs is expected to increase by 27 percent between 1976 and 2000, and by 44 percent between 2000 and 2040.

#### A. Production Areas

The production of Group V commodities in the PSAs is supplemented by production in Secondary Production Areas (SPAs) located outside the Ohio River Basin. These SPAs are defined as BEAs that are the origins of Group V waterborne movements destined to the Ohio River Basin.

Major SPA origins of grain shipped into the ORS hinterland include Iowa, Missouri, Minnesota, and Kansas, as well as other midwestern Corn Belt states. These Corn Belt states accounted for more than 15 percent of the interstate grain receipts of Alabama, Georgia, Kentucky, Mississippi, and Tennessee in 1970 (Table 10). Grain originating in the Corn Belt states was also destined for Ohio, Illinois, and Indiana, and included grains not grown locally in the quantities or qualities necessary to satisfy end-use demands. These included such grains as barley and rye for brewing and various wheats for flour.

The Tennessee River, the principal destination for grain inbound to the ORS hinterland, received most of its grain from the Illinois Waterway and the Missouri and Upper Mississippi Rivers. This grain included wheat produced in Kansas and Minnesota and shipped from BEA 91 (Minneapolis). BEA 91 shipments accounted for 34 percent of the Tennessee's grain receipts in 1976.

#### B. Production Characteristics

The factors that will determine future production of grains in the PSAs are economic, institutional, and technological in nature.

##### B-1. Corn, Wheat, and Soybeans

Total U.S. grain production increased rapidly during the third quarter of the twentieth century (Table 20). The major production increases occurred in soybeans, corn, and wheat, and production of the minor crops (oats, barley and rye) decreased. Soybean production increased 497 percent between 1950 and 1977, corn production increased by 108 percent, and wheat production increased 99 percent. These changes are a result of economic conditions, policies, educational and research programs, and the development of new technologies and innovations.

##### a. Economic Characteristics of Production

World economic conditions have fostered the growth in U.S. output of soybeans, corn, and wheat. Because of economic development, the world is demanding more meat and protein products. Soybeans have a comparative advantage as a source of protein. In addition, southern farmers have found soybeans to be an alternative crop to cotton. Meat production is primarily based on the consumption of corn and soybean meal, as well as roughages. Thus, the increased demand for meat in the United States and throughout the world has stimulated the demand and price of soybeans and corn.

In many countries of the developing world, cereals and flour are an important part of the diet. Again, wheat and rice have a comparative advantage in this important international food market. Increasing incomes and population growth have stimulated demand and, as a result, the price of wheat. Oats, barley, and rye have not been competitive products in supplying protein for either animals or people.

Table 20. United States: Grain Production and Yields for Wheat, Corn, and Soybeans,  
Selected Years, 1950-77

(Thousands of bushels, bushels per harvested acre)

| Year | Wheat      |       | Corn       |       | Soybeans   |       |
|------|------------|-------|------------|-------|------------|-------|
|      | Production | Yield | Production | Yield | Production | Yield |
| 1950 | 1,019      | 16.0  | 3,057      | 37.0  | 287        | 21.0  |
| 1960 | 1,354      | 26.0  | 3,906      | 54.0  | 555        | 23.0  |
| 1965 | 1,315      | 26.5  | 4,102      | 74.1  | 845        | 24.0  |
| 1970 | 1,351      | 31.0  | 4,152      | 72.4  | 1,127      | 27.0  |
| 1975 | 2,122      | 30.6  | 5,828      | 86.3  | 1,547      | 29.0  |
| 1977 | 2,025      | 30.6  | 6,357      | 90.8  | 1,716      | 30.0  |

Source: U.S. Department of Agriculture, Agricultural Statistics, selected years.

b. Institutional Characteristics  
of Production

United States agricultural programs have been an important stimulant for the production of feed grains and wheat. The programs began in earnest in the 1930s when farmers were caught in a serious price squeeze between income and expenses. The first Agricultural Adjustment Act was passed in 1933. Its purposes were to:

- . secure the voluntary reduction in acreage in basic crops;
- . eliminate unfair pricing practices of dealers and processors;
- . acquire tax funds to pay farmers not to produce;
- . follow improved conservation practices; and
- . provide an adequate supply of food with relative stable prices to consumers.

These programs primarily supported the price of corn and wheat. The minor crops were included, but most discussion and applications were in terms of wheat and corn. The government stockpiled large quantities of these products to ensure that the program would function.

These programs continued through the 1960s. New acts were passed by Congress, but the goals and purposes remained the same. In the late 1960s, the first world food shortage was recognized. This encouraged farmers to produce a maximum output of grain and livestock products. For most of the 1970s, grain was sold in a free market, and prices were free to fluctuate. Because of the spiraling prices, farmers produced record levels of corn, wheat, and soybeans.

By the end of the 1970s, consumers and livestock farmers were dissatisfied with fluctuating grain prices, and wheat farmers were sustaining losses. Thus, the political environment was again ripe for the institution of new programs. The names changed, but the ideas and goals remained the same as those in the earlier programs.

Under the Food and Agriculture Act of 1977, income support is provided to the participating producer through the target price

concept, which guarantees eligible producers a direct payment if farm prices received fall below established target prices. Deficiency, or target price, payments vary inversely with market prices. No payments are made if the national weighted average market price is at or above the target price.

The Food and Agriculture Act also provides price support loans. A producer complying with farm programs can commit any quantity of his crop as collateral for a loan from the Commodity Credit Corporation (CCC). The total amount that can be borrowed is equal to the quantity of the crop placed under loan times the loan rate. Compliance with average set-aside provisions is a condition for loan eligibility.

A normal crop acreage set-aside program<sup>1</sup> is implemented if the Secretary of Agriculture determines that supplies of a designated commodity are likely to be excessive. The purpose of such a program is to bring supplies into better balance with anticipated demand over a period of time, by curbing production through acreage cutbacks. Consideration is given to the need for adequate carry-over to maintain reasonable and stable supplies and prices and to meet any national emergency.

Under the Food and Agricultural Act of 1977, there was a 20 percent set-aside for the 1978 wheat crop. The basic program requirement was that farmers set aside an acreage equal to 20 percent of their 1978 wheat plantings. The set-aside acreage must be protected by an approved cover crop or other approved conservation practices, such as stubble or stubble mulch. The program includes target prices, loan rates, payment limitations, and grain reserves.

---

1. Acreage set-aside is that which is removed from production, and in any year is based on a farmer's acreage planted for harvest in that year. Acreage set-aside must be cropland that was tilled within the previous three years for a crop other than hay or pasture. And, when set-aside requirements for a crop planted on the farm are in effect, a farm's acreage planted to designated crops plus any set-aside cannot exceed the established normal crop acreage in order for the farm to be eligible for program benefits. Compliance with acreage set-aside provisions for each of the programs for wheat, feed grains, cotton, or rice is a condition of eligibility for loans, purchases, or payments, on any designated commodity produced. (For further discussion see Commodity Research Bureau, Inc., Commodity Yearbook, published in New York, 1978.)

Corn is subject to provisions of the Food and Agricultural Act of 1977 and the 1978 Feed Grain Production Program. The terminology and purposes are similar to those specified in the Wheat Program. The national average loan rate for 1978 was \$2.00/bushel, and the target price was \$2.10/bushel. Loans on the 1978 crop were expected to be available to farmers through May 31, 1979, with a loan maturity date nine months from loan application date. Again, the requirements and payments may vary as specified by the Secretary of Agriculture.

The Food and Agricultural Act of 1977 covers the 1978 through 1981 crops and is designed to bring supply and demand into balance by making it attractive for farmers to reduce production and to make use of a three-year grain reserve. Its success in supporting prices will depend upon the extent to which producers participate in these programs and upon weather and climatic conditions and technological changes.

It is anticipated that the program will re-establish stable grain and food prices for consumers and profit levels that are acceptable to farmers. In addition, there should be a stable, adequate supply of food for U.S. consumers and a reserve of food for emergency purposes. If accepted by farmers, the rate of growth in grain production may be retarded. However, it is doubtful that U.S. grain production will be declining because of the world economic conditions.

Agricultural extension programs and research efforts continue to increase yields and agricultural output. The extension programs began in earnest in the 19th century. All land grant universities have strong agricultural schools that are committed to improving the economic well-being of farmers. This is a strong force which has increased the productivity of U.S. agriculture.

Extension programs are geared toward the education of the farmer through demonstration. Through extension, the farmer is provided information on seeding, fertilization, harvesting, and marketing. Valuable information is provided on the economic impact of the implementation of certain government policies on the individual operation.

c. Technological Characteristics  
of Production

Until World War I, U.S. farm output was a function of the amount of cropland under cultivation and available animal power.

Starting in the 1920s, animal power was replaced by the internal-combustion engine, but output did not increase significantly because cropland did not expand. The decrease in output of the early 1930s, caused by the Depression, was followed by rapid growth after 1935 in response to a drive toward more intense use of land resources. Between 1940 and 1965, agricultural production in the U.S. grew by two-thirds. Even more remarkable was the rapid growth in grain output from the period of 1950 to 1977 (Table 20). Wheat yields, for example, increased from 16 bushels per acre to 30.6 bushels; soybean yields increased from 21 bushels to 30 bushels; and corn yields increased from 37 bushels per acre to 90.8 bushels.

As can be seen in Tables 21, 22, and 23, for corn, wheat, and soybeans, respectively, during 1969-76 the PSAs frequently had yields per harvested acre that were greater than those of the United States as a whole. In the ORS hinterland, yields were the greatest in the midwestern PSAs (i.e., in Ohio, Illinois, and Indiana). However, large increases in acres harvested of all three principal crops, particularly in soybeans, occurred in the south-eastern PSAs. In many cases, soybean acres harvested doubled between 1969 and 1976 (Table 23).

It is important to note that of the three principal crops, corn yields almost three times as many bushels per harvested acre as wheat or soybeans. Therefore, the decision to grow corn affects the amount of grain (in weight terms) that is available to be transported at any one time or by any one mode.

Based on the changes in yields, it is obvious that changes in technologies such as the introduction of hybrid seeds, fertilizers, herbicides, insecticides, and new machinery have more than offset restrictive agricultural production policies. In one sense, there appears to be a paradox: reduction in production on the one hand versus increased production on the other. Instead, observe that the underlying goals are consistent in both programs: to provide a stable adequate supply of food for people at a price that will ensure an adequate income for U.S. farmers.

Weather can have an adverse, although generally short-term, effect on grain production. Bad weather can delay planting, fertilization, and second cropping; force abandonment of planted acres; and substantially lower yields.



BEA and BEA Segment, Average Harvested Acres and Yield per Acre,  
by BEA or BEA Segment, 1969-76

Source: U.S. Department of Agriculture, Bureau of Economic Analysis, based on data from the National Agricultural Statistics Service, Washington, D.C.

| BEA and BEA segment            | 1969        | 1970        | 1971        | 1972        | 1973        | 1974        | 1975        | 1976        |
|--------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| <u>United States</u>           |             |             |             |             |             |             |             |             |
| Production                     | 4,687,057.0 | 4,151,938.0 | 5,641,112.0 | 5,573,320.0 | 5,646,806.0 | 4,663,631.0 | 5,828,961.0 | 6,266,359.0 |
| Acres harvested                | 54,574.0    | 57,358.0    | 64,047.0    | 57,421.0    | 61,894.0    | 65,357.0    | 67,555.0    | 71,300.0    |
| Yield per acre                 | 85.9        | 72.4        | 88.1        | 97.1        | 91.2        | 71.4        | 86.3        | 87.9        |
| <u>Primary Study Areas</u>     |             |             |             |             |             |             |             |             |
| Production                     | 412,209.1   | 308,627.8   | 484,434.0   | 446,112.6   | 444,462.7   | 426,097.3   | 486,643.5   | 671,252.8   |
| Acres harvested                | 5,074.8     | 5,176.7     | 5,809.0     | 4,959.2     | 5,211.2     | 5,552.8     | 5,751.5     | 6,601.1     |
| Yield per acre                 | 81.2        | 59.6        | 83.4        | 90.0        | 85.3        | 76.7        | 84.6        | 101.7       |
| <u>BEA 44: Atlanta, GA</u>     |             |             |             |             |             |             |             |             |
| Production                     | 993.2       | 634.0       | 1,194.0     | 1,248.9     | 1,069.3     | 1,273.0     | 1,260.3     | 1,467.7     |
| Acres harvested                | 23.6        | 21.0        | 24.2        | 25.3        | 20.2        | 22.8        | 21.1        | 25.7        |
| Yield per acre                 | 42.2        | 30.2        | 49.4        | 49.5        | 53.0        | 55.9        | 59.6        | 57.0        |
| <u>BEA 45: Birmingham, AL</u>  |             |             |             |             |             |             |             |             |
| Production                     | 4,234.0     | 2,787.0     | 4,250.2     | 3,646.1     | 4,120.9     | 4,271.1     | 5,386.2     | 5,455.2     |
| Acres harvested                | 122.2       | 105.2       | 100.1       | 76.0        | 85.8        | 90.0        | 99.6        | 100.0       |
| Yield per acre                 | 34.7        | 26.5        | 42.5        | 48.0        | 48.1        | 47.5        | 54.1        | 54.6        |
| <u>BEA 46: Memphis, TN</u>     |             |             |             |             |             |             |             |             |
| Production                     | 4,854.2     | 3,865.4     | 7,146.0     | 6,881.0     | 6,194.7     | 6,113.2     | 7,145.3     | 10,043.3    |
| Acres harvested                | 99.0        | 98.0        | 123.1       | 88.9        | 95.6        | 100.3       | 114.6       | 135.7       |
| Yield per acre                 | 49.0        | 39.4        | 58.1        | 77.4        | 64.8        | 60.9        | 62.3        | 74.0        |
| <u>BEA 47: Huntsville, AL</u>  |             |             |             |             |             |             |             |             |
| Production                     | 4,981.5     | 4,027.0     | 6,733.3     | 4,906.0     | 5,230.1     | 5,658.6     | 7,437.1     | 9,733.3     |
| Acres harvested                | 143.1       | 123.3       | 144.0       | 90.8        | 97.8        | 104.7       | 122.3       | 137.9       |
| Yield per acre                 | 34.9        | 32.7        | 46.9        | 54.0        | 53.5        | 54.0        | 60.8        | 70.6        |
| <u>BEA 48: Chattanooga, TN</u> |             |             |             |             |             |             |             |             |
| Production                     | 4,211.8     | 2,969.0     | 5,394.0     | 5,475.3     | 6,270.6     | 5,487.5     | 6,852.1     | 10,728.7    |
| Acres harvested                | 88.0        | 79.7        | 95.8        | 85.1        | 96.3        | 94.9        | 102.3       | 143.0       |
| Yield per acre                 | 47.9        | 37.3        | 56.3        | 64.4        | 65.1        | 57.8        | 67.0        | 75.1        |

(Continued)

Table 21.(Continued)

| BEA and BEA segment            | 1969      | 1970     | 1971      | 1972      | 1973     | 1974     | 1975      | 1976      |
|--------------------------------|-----------|----------|-----------|-----------|----------|----------|-----------|-----------|
| <u>BEA 49: Nashville, TN</u>   |           |          |           |           |          |          |           |           |
| Production                     | 22,908.9  | 17,583.7 | 30,769.0  | 28,159.9  | 30,084.7 | 29,376.6 | 27,940.4  | 49,017.2  |
| Acres harvested                | 373.3     | 362.0    | 464.5     | 369.7     | 403.8    | 413.9    | 457.9     | 536.3     |
| Yield per acre                 | 61.4      | 48.6     | 66.2      | 76.2      | 74.5     | 71.0     | 61.0      | 91.4      |
| <u>BEA 50: Knoxville, TN</u>   |           |          |           |           |          |          |           |           |
| Production                     | 1,622.1   | 1,402.0  | 2,030.0   | 2,346.0   | 2,161.0  | 2,161.0  | 2,410.0   | 3,451.0   |
| Acres harvested                | 27.1      | 28.2     | 33.9      | 34.2      | 39.5     | 34.5     | 38.4      | 44.7      |
| Yield per acre                 | 59.9      | 49.7     | 59.9      | 68.6      | 72.7     | 62.6     | 62.8      | 77.2      |
| <u>BEA 52: Huntington, WV</u>  |           |          |           |           |          |          |           |           |
| Production                     | 2,366.1   | 1,516.6  | 2,590.7   | 2,479.6   | 2,535.1  | 2,677.7  | 2,906.3   | 3,266.7   |
| Acres harvested                | 31.4      | 29.4     | 36.6      | 32.3      | 33.8     | 37.2     | 36.1      | 36.8      |
| Yield per acre                 | 75.4      | 51.6     | 70.8      | 76.8      | 75.0     | 72.0     | 80.5      | 88.8      |
| <u>BEA 53: Lexington, KY</u>   |           |          |           |           |          |          |           |           |
| Production                     | 8,224.0   | 6,379.5  | 11,429.8  | 11,228.4  | 11,637.1 | 11,969.8 | 10,304.6  | 14,318.1  |
| Acres harvested                | 106.8     | 107.9    | 150.7     | 133.1     | 136.0    | 144.1    | 142.1     | 144.2     |
| Yield per acre                 | 77.0      | 59.1     | 75.8      | 84.4      | 85.6     | 83.1     | 72.5      | 99.3      |
| <u>BEA 54: Louisville, KY</u>  |           |          |           |           |          |          |           |           |
| Production                     | 19,829.9  | 12,722.6 | 23,924.2  | 23,368.6  | 25,736.8 | 26,065.7 | 22,898.9  | 36,033.5  |
| Acres harvested                | 240.1     | 245.3    | 307.2     | 268.0     | 297.0    | 329.3    | 340.8     | 366.4     |
| Yield per acre                 | 82.6      | 51.9     | 77.9      | 87.2      | 86.7     | 79.2     | 67.2      | 98.3      |
| <u>BEA 55: Evansville, IN</u>  |           |          |           |           |          |          |           |           |
| Production                     | 100,218.6 | 58,637.1 | 194,990.7 | 105,999.8 | 99,166.7 | 95,234.8 | 117,139.7 | 153,324.6 |
| Acres harvested                | 1,180.9   | 1,199.1  | 1,216.6   | 1,085.9   | 1,114.7  | 1,171.1  | 1,254.2   | 1,451.8   |
| Yield per acre                 | 84.9      | 48.9     | 86.3      | 97.6      | 89.0     | 81.3     | 93.4      | 105.6     |
| <u>BEA 56: Terre Haute, IN</u> |           |          |           |           |          |          |           |           |
| Production                     | 8,336.6   | 7,381.7  | 11,076.2  | 7,395.9   | 11,263.6 | 7,171.1  | 11,365.4  | 13,866.9  |
| Acres harvested                | 94.9      | 102.7    | 108.2     | 89.0      | 108.7    | 102.0    | 109.8     | 133.1     |
| Yield per acre                 | 87.8      | 71.9     | 102.4     | 105.6     | 103.6    | 70.3     | 103.5     | 104.2     |

(Continued)

Table 21. (Continued)

| BEA and BEA segment             | 1969     | 1970     | 1971     | 1972     | 1973     | 1974     | 1975     | 1976      |
|---------------------------------|----------|----------|----------|----------|----------|----------|----------|-----------|
| <b>BEA 60: Indianapolis, IN</b> |          |          |          |          |          |          |          |           |
| Production                      |          | 61,649.2 | 89,642.7 | 83,634.6 | 89,224.1 | 67,712.7 | 80,398.2 | 113,898.3 |
| Acres harvested                 | 78,476.1 | 842.0    | 898.9    | 803.9    | 861.0    | 885.0    | 871.0    | 983.5     |
| Yield per acre                  | 793.8    | 73.2     | 99.7     | 104.1    | 103.6    | 76.5     | 92.3     | 115.8     |
|                                 | 98.9     |          |          |          |          |          |          |           |
| <b>BEA 61: Anderson, IN</b>     |          |          |          |          |          |          |          |           |
| Production                      | 10,180.9 | 8,651.2  | 11,764.8 | 10,082.3 | 11,036.3 | 10,333.3 | 11,680.3 | 17,338.4  |
| Acres harvested                 | 105.3    | 107.9    | 130.1    | 106.9    | 110.8    | 129.6    | 141.1    | 161.5     |
| Yield per acre                  | 96.7     | 80.2     | 90.4     | 94.3     | 99.6     | 79.7     | 82.8     | 107.4     |
| <b>BEA 62: Cincinnati, OH</b>   |          |          |          |          |          |          |          |           |
| Production                      | 38,012.1 | 28,381.2 | 42,576.4 | 37,045.3 | 37,286.1 | 38,856.7 | 40,626.1 | 55,818.7  |
| Acres harvested                 | 422.7    | 420.9    | 494.8    | 432.7    | 436.6    | 491.1    | 476.7    | 535.6     |
| Yield per acre                  | 89.9     | 67.4     | 86.0     | 85.6     | 85.4     | 79.1     | 85.2     | 104.2     |
| <b>BEA 63: Dayton, OH</b>       |          |          |          |          |          |          |          |           |
| Production                      | 46,771.0 | 45,596.0 | 62,451.0 | 52,826.0 | 48,418.0 | 53,327.5 | 61,492.0 | 74,077.0  |
| Acres harvested                 | 507.5    | 559.0    | 662.9    | 568.7    | 580.7    | 640.2    | 628.5    | 687.1     |
| Yield per acre                  | 92.2     | 81.6     | 94.2     | 92.9     | 83.4     | 83.3     | 97.8     | 107.8     |
| <b>BEA 64: Columbus, OH</b>     |          |          |          |          |          |          |          |           |
| Production                      | 37,839.0 | 33,584.0 | 45,214.0 | 38,756.0 | 35,910.7 | 42,366.6 | 44,779.0 | 61,554.0  |
| Acres harvested                 | 422.2    | 45.5     | 507.8    | 434.7    | 465.2    | 525.6    | 501.0    | 561.9     |
| Yield per acre                  | 89.6     | 73.7     | 89.2     | 89.2     | 77.2     | 80.6     | 89.4     | 109.5     |
| <b>BEA 114: St. Louis, MO</b>   |          |          |          |          |          |          |          |           |
| Production                      | 8,104.0  | 5,470.3  | 8,777.6  | 8,977.6  | 6,939.8  | 5,530.7  | 10,595.6 | 11,987.6  |
| Acres harvested                 | 154.6    | 158.4    | 140.6    | 117.1    | 103.6    | 96.1     | 130.6    | 154.0     |
| Yield per acre                  | 52.4     | 34.5     | 62.4     | 76.7     | 67.0     | 57.6     | 81.1     | 77.8      |
| <b>BEA 115: Paducah, KY</b>     |          |          |          |          |          |          |          |           |
| Production                      | 10,045.1 | 5,390.3  | 12,479.4 | 9,595.3  | 9,467.1  | 10,511.7 | 14,076.0 | 25,872.6  |
| Acres harvested                 | 138.4    | 131.3    | 169.1    | 117.0    | 124.1    | 140.4    | 163.5    | 261.9     |
| Yield per acre                  | 72.6     | 41.1     | 73.8     | 82.0     | 76.3     | 74.9     | 86.1     | 98.8      |

Note: Individual items may not equal total due to rounding. Corn is corn for grain.

a. BEA segments defined as counties which are ultimate origins for destinations of waterborne movements.  
 Source: U.S. production, acreage harvested, and yield data for 1969 to 1974 from U.S. Department of Agriculture, Agricultural Statistics, 1977; data for 1975 and 1976 from U.S. Department of Agriculture, Crop Production; 1977 Annual Summary; Acreage, Yield and Production, January 1978. BEA and BEA segment level data estimated from production data provided annually for 1969-76 by the U.S. Department of Agriculture, Crop Reporting Services of the states of Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio, and Tennessee.

Table 22. United States and Ohio River Basin: Wheat Production, Acreage Harvested, and Yield Per Acre,  
by BEAs or BEA Segmentsa, 1969-76

(Thousands of bushels, thousands of acres, bushels per acre harvested)

| BEA and BEA segment            | 1969        | 1970        | 1971        | 1972        | 1973        | 1974        | 1975        | 1976        |
|--------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| <u>United States</u>           |             |             |             |             |             |             |             |             |
| Production                     | 1,442,679.0 | 1,351,558.0 | 1,617,789.0 | 1,544,936.0 | 1,705,167.0 | 1,796,187.0 | 2,134,833.0 | 2,147,408.0 |
| Acres harvested                | 47,146.0    | 43,564.0    | 47,674.0    | 47,284.0    | 53,869.0    | 65,613.0    | 69,641.0    | 70,824.0    |
| Yield per acre                 | 30.6        | 31.0        | 33.9        | 32.7        | 31.6        | 27.3        | 30.6        | 30.3        |
| <u>Primary Study Areas</u>     |             |             |             |             |             |             |             |             |
| Production                     | 42,403.7    | 39,016.4    | 48,567.5    | 52,023.8    | 35,739.3    | 63,303.2    | 70,523.6    | 69,135.9    |
| Acres harvested                | 1,164.6     | 1,059.2     | 1,117.1     | 1,293.8     | 1,174.0     | 1,925.0     | 1,872.5     | 1,923.4     |
| Yield per acre                 | 36.4        | 36.8        | 43.5        | 40.2        | 30.4        | 32.9        | 37.7        | 35.9        |
| <u>BEA 44: Atlanta, GA</u>     |             |             |             |             |             |             |             |             |
| Production                     | 106.6       | 108.0       | 183.3       | 108.9       | 84.7        | 254.0       | 247.7       | 324.8       |
| Acres harvested                | 3.4         | 3.1         | 5.0         | 4.1         | 2.7         | 7.9         | 8.9         | 9.7         |
| Yield per acre                 | 31.5        | 35.3        | 36.6        | 26.4        | 31.1        | 32.3        | 27.9        | 33.4        |
| <u>BEA 45: Birmingham, AL</u>  |             |             |             |             |             |             |             |             |
| Production                     | 107.1       | 119.1       | 198.4       | 163.8       | 125.8       | 191.7       | 231.6       | 242.1       |
| Acres harvested                | 3.4         | 3.8         | 6.4         | 5.8         | 5.6         | 7.0         | 8.4         | 7.7         |
| Yield per acre                 | 31.6        | 31.4        | 31.0        | 28.4        | 22.7        | 27.4        | 27.6        | 31.6        |
| <u>BEA 46: Memphis, TN</u>     |             |             |             |             |             |             |             |             |
| Production                     | 432.0       | 662.8       | 774.8       | 741.5       | 508.5       | 873.1       | 866.3       | 1,098.8     |
| Acres harvested                | 12.8        | 17.9        | 21.6        | 23.6        | 17.7        | 30.0        | 29.4        | 30.8        |
| Yield per acre                 | 33.9        | 37.0        | 35.9        | 31.4        | 28.7        | 29.1        | 29.5        | 35.7        |
| <u>BEA 47: Huntsville, AL</u>  |             |             |             |             |             |             |             |             |
| Production                     | 960.6       | 1,091.2     | 1,396.1     | 1,321.8     | 833.4       | 1,617.9     | 1,702.5     | 1,589.2     |
| Acres harvested                | 28.4        | 31.7        | 39.5        | 41.6        | 27.7        | 50.9        | 56.1        | 45.4        |
| Yield per acre                 | 33.8        | 34.4        | 35.4        | 31.8        | 30.1        | 31.8        | 30.4        | 35.0        |
| <u>BEA 48: Chattanooga, TN</u> |             |             |             |             |             |             |             |             |
| Production                     | 250.4       | 250.9       | 372.2       | 339.1       | 248.2       | 420.3       | 470.2       | 416.7       |
| Acres harvested                | 4.1         | 7.0         | 10.5        | 10.9        | 8.3         | 13.7        | 14.7        | 12.7        |
| Yield per acre                 | 60.8        | 35.8        | 35.6        | 31.3        | 29.9        | 30.8        | 32.0        | 32.7        |

(Continued)

Table 22. (Continued)

| BEA and BEA segment            | 1969    | 1970    | 1971     | 1972     | 1973    | 1974     | 1975     | 1976     |
|--------------------------------|---------|---------|----------|----------|---------|----------|----------|----------|
| <u>BEA 49: Nashville, TN</u>   |         |         |          |          |         |          |          |          |
| Production                     | 4,236.4 | 4,282.4 | 4,903.9  | 4,733.1  | 2,916.4 | 6,712.6  | 6,812.8  | 6,915.0  |
| Acres harvested                | 121.7   | 115.6   | 126.0    | 142.0    | 84.6    | 217.3    | 207.5    | 217.4    |
| Yield per acre                 | 34.8    | 37.1    | 38.9     | 33.3     | 34.5    | 30.9     | 32.8     | 31.8     |
| <u>BEA 50: Knoxville, TN</u>   |         |         |          |          |         |          |          |          |
| Production                     | 224.4   | 255.8   | 263.6    | 273.2    | 227.3   | 349.0    | 357.3    | 443.7    |
| Acres harvested                | 6.3     | 7.1     | 7.0      | 8.4      | 7.1     | 11.0     | 10.8     | 11.8     |
| Yield per acre                 | 35.9    | 36.0    | 37.9     | 32.7     | 32.0    | 31.7     | 33.1     | 37.6     |
| <u>BEA 52: Huntington, WV</u>  |         |         |          |          |         |          |          |          |
| Production                     | 106.8   | 81.7    | 99.1     | 100.8    | 89.1    | 118.4    | 122.7    | 108.8    |
| Acres harvested                | 3.1     | 2.7     | 2.9      | 3.0      | 3.2     | 4.1      | 4.1      | 3.7      |
| Yield per acre                 | 34.8    | 30.0    | 34.7     | 34.1     | 27.5    | 28.9     | 30.3     | 29.8     |
| <u>BEA 53: Lexington, KY</u>   |         |         |          |          |         |          |          |          |
| Production                     | 444.4   | 424.1   | 582.2    | 503.3    | 427.2   | 594.1    | 562.3    | 527.6    |
| Acres harvested                | 14.4    | 12.9    | 15.5     | 15.9     | 13.8    | 19.6     | 17.9     | 17.3     |
| Yield per acre                 | 30.9    | 32.8    | 37.5     | 31.8     | 31.0    | 30.3     | 31.4     | 30.5     |
| <u>BEA 54: Louisville, KY</u>  |         |         |          |          |         |          |          |          |
| Production                     | 1,567.9 | 1,376.1 | 1,721.9  | 1,937.5  | 1,803.9 | 3,412.9  | 3,051.0  | 2,184.5  |
| Acres harvested                | 46.4    | 39.9    | 42.8     | 55.6     | 54.1    | 107.4    | 88.0     | 81.6     |
| Yield per acre                 | 33.8    | 34.5    | 40.2     | 34.8     | 33.3    | 31.8     | 34.7     | 26.8     |
| <u>BEA 55: Evansville, IN</u>  |         |         |          |          |         |          |          |          |
| Production                     | 8,853.2 | 7,320.2 | 10,112.6 | 11,543.6 | 9,502.8 | 14,121.3 | 14,284.8 | 14,207.1 |
| Acres harvested                | 247.3   | 211.0   | 220.2    | 286.3    | 309.5   | 460.5    | 393.9    | 417.0    |
| Yield per acre                 | 35.8    | 34.7    | 45.9     | 40.3     | 30.7    | 30.7     | 36.3     | 34.1     |
| <u>BEA 56: Terre Haute, IN</u> |         |         |          |          |         |          |          |          |
| Production                     | 802.3   | 654.4   | 825.8    | 1,098.1  | 732.6   | 1,297.7  | 1,536.1  | 1,418.1  |
| Acres harvested                | 23.4    | 17.3    | 18.9     | 23.7     | 21.2    | 42.2     | 40.8     | 42.9     |
| Yield per acre                 | 34.3    | 37.3    | 43.7     | 46.3     | 34.6    | 30.8     | 37.7     | 33.1     |

(Continued)

Table 22. (Continued)

| BEA and BEA segment             | 1969    | 1970    | 1971    | 1972    | 1973    | 1974    | 1975     | 1976     |
|---------------------------------|---------|---------|---------|---------|---------|---------|----------|----------|
| <b>BEA 60: Indianapolis, IN</b> |         |         |         |         |         |         |          |          |
| Production                      | 5,327.2 | 4,659.2 | 5,101.8 | 6,367.2 | 4,186.1 | 7,554.7 | 9,125.1  | 8,030.9  |
| Acres harvested                 | 131.8   | 112.6   | 104.8   | 129.4   | 117.8   | 206.3   | 201.8    | 219.4    |
| Yield per acre                  | 40.4    | 41.3    | 48.7    | 49.2    | 35.5    | 36.6    | 45.2     | 36.6     |
| <b>BEA 61: Anderson, IN</b>     |         |         |         |         |         |         |          |          |
| Production                      | 699.2   | 689.6   | 678.6   | 751.5   | 486.0   | 1,170.7 | 1,304.3  | 1,310.6  |
| Acres harvested                 | 18.4    | 16.1    | 14.4    | 15.2    | 14.8    | 30.1    | 28.9     | 30.6     |
| Yield per acre                  | 37.5    | 42.8    | 47.1    | 49.4    | 32.8    | 38.9    | 45.1     | 42.8     |
| <b>BEA 62: Cincinnati, OH</b>   |         |         |         |         |         |         |          |          |
| Production                      | 4,001.9 | 3,708.1 | 4,190.1 | 3,896.1 | 2,582.3 | 4,490.6 | 4,892.1  | 5,018.7  |
| Acres harvested                 | 114.7   | 104.0   | 99.8    | 101.4   | 103.3   | 139.7   | 134.8    | 140.8    |
| Yield per acre                  | 34.9    | 35.7    | 42.0    | 38.4    | 25.0    | 32.1    | 36.3     | 35.6     |
| <b>BEA 63: Dayton, OH</b>       |         |         |         |         |         |         |          |          |
| Production                      | 6,002.0 | 5,371.0 | 6,842.0 | 6,969.0 | 4,297.0 | 8,266.1 | 10,930.8 | 10,285.6 |
| Acres harvested                 | 149.6   | 131.7   | 142.9   | 147.0   | 131.6   | 203.7   | 244.7    | 239.5    |
| Yield per acre                  | 40.1    | 40.8    | 47.9    | 47.4    | 32.7    | 40.6    | 44.7     | 42.9     |
| <b>BEA 64: Columbus, OH</b>     |         |         |         |         |         |         |          |          |
| Production                      | 5,336.3 | 4,944.8 | 5,754.6 | 5,856.2 | 3,426.0 | 6,947.4 | 8,132.0  | 8,184.4  |
| Acres harvested                 | 137.4   | 133.8   | 130.6   | 135.9   | 116.0   | 182.6   | 209.3    | 205.6    |
| Yield per acre                  | 38.8    | 37.0    | 44.1    | 43.1    | 29.5    | 38.0    | 38.9     | 39.8     |
| <b>BEA 114: St. Louis, MO</b>   |         |         |         |         |         |         |          |          |
| Production                      | 1,811.4 | 1,684.4 | 2,826.4 | 3,635.3 | 2,234.2 | 2,568.8 | 3,406.5  | 4,045.5  |
| Acres harvested                 | 62.9    | 51.0    | 61.4    | 86.3    | 95.2    | 104.4   | 96.0     | 106.6    |
| Yield per acre                  | 28.8    | 33.0    | 46.0    | 42.1    | 23.5    | 24.6    | 35.5     | 38.0     |
| <b>BEA 115: Paducah, KY</b>     |         |         |         |         |         |         |          |          |
| Production                      | 1,143.6 | 1,342.6 | 1,740.2 | 1,683.8 | 1,027.8 | 2,342.0 | 2,487.5  | 2,783.8  |
| Acres harvested                 | 35.3    | 39.9    | 47.1    | 58.0    | 39.9    | 86.7    | 76.5     | 82.9     |
| Yield per acre                  | 32.4    | 33.6    | 36.9    | 29.0    | 25.8    | 27.0    | 32.5     | 33.6     |

Note: Individual items may not equal total due to rounding. Wheat is all wheat.

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

Source: U.S. production, acreage harvested, and yield data for 1969 to 1974 from U.S. Department of Agriculture, Agricultural Statistics, 1977; data for 1975 and 1976 from U.S. Department of Agriculture, Crop Production; 1977 Annual Summary; Acreage, Yield and Production, January 1978. BEA and BEA segment level data estimated from production data provided annually for 1969-76 by the U.S. Department of Agriculture, Crop Reporting Services of the states of Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio, and Tennessee.

Table 23. United States and BEA Segment Production, Acres Harvested and Yield Per Acre, by State or BEA Segment, 1969-76

(Thousands of bushels, thousands of acres, bushels per acre harvested)

| BEA and BEA Segment            | 1969        | 1970        | 1971        | 1972        | 1973        | 1974        | 1975        | 1976        |
|--------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| <u>United States</u>           |             |             |             |             |             |             |             |             |
| Production                     | 1,113,630.0 | 1,127,100.0 | 1,175,989.0 | 1,270,630.0 | 1,547,165.0 | 1,214,802.0 | 1,547,383.0 | 1,287,560.0 |
| Acres harvested                | 41,337.6    | 42,249.0    | 42,701.0    | 45,698.0    | 55,796.0    | 52,368.0    | 53,579.0    | 49,358.0    |
| Yield per acre                 | 27.4        | 26.7        | 27.5        | 27.8        | 27.7        | 23.2        | 28.9        | 26.1        |
| <u>Primary Study Areas</u>     |             |             |             |             |             |             |             |             |
| <u>BEA 44: Atlanta, GA</u>     |             |             |             |             |             |             |             |             |
| Production                     | 104,710.7   | 98,862.4    | 120,739.4   | 125,176.3   | 146,641.9   | 134,051.6   | 164,796.6   | 156,446.4   |
| Acres harvested                | 3,510.8     | 3,521.9     | 4,007.5     | 4,672.2     | 5,524.4     | 5,315.1     | 5,791.7     | 5,238.0     |
| Yield per acre                 | 29.8        | 28.1        | 30.1        | 26.8        | 26.5        | 25.2        | 28.5        | 29.9        |
| <u>BEA 45: Birmingham, AL</u>  |             |             |             |             |             |             |             |             |
| Production                     | 575.6       | 416.0       | 436.5       | 385.4       | 709.6       | 986.2       | 1,589.5     | 1,226.8     |
| Acres harvested                | 24.1        | 18.9        | 15.3        | 18.7        | 32.5        | 43.2        | 58.7        | 50.6        |
| Yield per acre                 | 23.9        | 22.0        | 28.5        | 20.6        | 21.8        | 22.9        | 27.1        | 24.3        |
| <u>BEA 46: Memphis, TN</u>     |             |             |             |             |             |             |             |             |
| Production                     | 4,684.5     | 4,151.9     | 4,655.1     | 4,340.9     | 5,314.0     | 5,364.7     | 7,586.6     | 8,588.4     |
| Acres harvested                | 178.5       | 185.3       | 190.5       | 221.9       | 283.5       | 294.3       | 367.0       | 363.4       |
| Yield per acre                 | 22.9        | 22.4        | 24.4        | 19.6        | 18.7        | 18.2        | 20.7        | 23.6        |
| <u>BEA 47: Huntsville, AL</u>  |             |             |             |             |             |             |             |             |
| Production                     | 4,021.0     | 3,747.0     | 4,442.0     | 4,189.0     | 4,693.0     | 4,657.0     | 6,662.9     | 5,621.6     |
| Acres harvested                | 168.8       | 164.5       | 171.6       | 184.8       | 214.1       | 215.9       | 277.9       | 269.8       |
| Yield per acre                 | 23.8        | 22.8        | 25.9        | 22.7        | 21.9        | 21.6        | 24.0        | 20.8        |
| <u>BEA 48: Chattanooga, TN</u> |             |             |             |             |             |             |             |             |
| Production                     | 5,063.7     | 4,823.5     | 6,649.0     | 6,380.0     | 7,786.0     | 8,077.0     | 11,885.5    | 10,747.0    |
| Acres harvested                | 219.9       | 219.9       | 255.7       | 296.8       | 376.1       | 382.6       | 484.9       | 461.8       |
| Yield per acre                 | 23.0        | 21.9        | 26.0        | 21.5        | 20.7        | 21.1        | 24.5        | 23.3        |
| <u>BEA 49: Chattanooga, TN</u> |             |             |             |             |             |             |             |             |
| Production                     | 1,125.0     | 1,064.3     | 1,374.7     | 1,641.2     | 1,802.8     | 2,256.2     | 2,651.5     | 2,175.5     |
| Acres harvested                | 48.1        | 48.5        | 55.9        | 76.2        | 88.7        | 105.9       | 118.3       | 101.1       |
| Yield per acre                 | 23.4        | 21.9        | 24.6        | 21.5        | 20.5        | 21.3        | 22.4        | 21.5        |

Table 23. (Continued)

| BEA and BEA segment             | 1969     | 1970     | 1971     | 1972     | 1973     | 1974     | 1975     | 1976     |
|---------------------------------|----------|----------|----------|----------|----------|----------|----------|----------|
| <u>BEA 49: Nashville, TN</u>    |          |          |          |          |          |          |          |          |
| Production                      | 2,420.0  | 2,734.0  | 4,638.7  | 7,153.9  | 9,101.7  | 9,392.4  | 10,966.0 | 12,290.5 |
| Acres harvested                 | 94.4     | 105.8    | 157.7    | 270.9    | 351.2    | 378.3    | 423.8    | 456.1    |
| Yield per acre                  | 25.6     | 25.8     | 29.4     | 26.4     | 25.9     | 24.8     | 25.9     | 26.9     |
| <u>BEA 50: Knoxville, TN</u>    |          |          |          |          |          |          |          |          |
| Production                      | 158.6    | 136.5    | 187.6    | 145.0    | 209.0    | 295.5    | 291.1    | 267.9    |
| Acres harvested                 | 5.7      | 5.5      | 7.1      | 6.6      | 9.4      | 12.0     | 12.9     | 11.6     |
| Yield per acre                  | 27.8     | 25.0     | 26.4     | 22.0     | 22.2     | 24.6     | 22.6     | 23.1     |
| <u>BEA 52: Huntington, WV</u>   |          |          |          |          |          |          |          |          |
| Production                      | 130.3    | 139.5    | 201.8    | 175.1    | 262.9    | 273.9    | 395.5    | 354.4    |
| Acres harvested                 | 4.3      | 5.0      | 7.3      | 7.4      | 10.4     | 11.3     | 11.9     | 11.2     |
| Yield per acre                  | 30.6     | 28.0     | 27.6     | 23.6     | 25.2     | 24.2     | 33.1     | 31.6     |
| <u>BEA 53: Lexington, KY</u>    |          |          |          |          |          |          |          |          |
| Production                      | 40.5     | 46.0     | 116.2    | 86.6     | 99.3     | 153.9    | 264.1    | 348.0    |
| Acres harvested                 | 1.5      | 1.8      | 4.3      | 3.4      | 4.0      | 7.1      | 11.7     | 12.6     |
| Yield per acre                  | 27.0     | 26.0     | 26.9     | 25.7     | 24.9     | 21.6     | 22.5     | 27.5     |
| <u>BEA 54: Louisville, KY</u>   |          |          |          |          |          |          |          |          |
| Production                      | 2,746.2  | 2,604.1  | 3,049.0  | 3,239.3  | 3,137.6  | 3,237.1  | 3,116.5  | 3,288.7  |
| Acres harvested                 | 90.1     | 91.3     | 106.6    | 122.9    | 128.7    | 132.3    | 130.7    | 116.2    |
| Yield per acre                  | 30.5     | 28.5     | 28.6     | 26.4     | 24.4     | 24.5     | 23.8     | 28.3     |
| <u>BEA 55: Evansville, IN</u>   |          |          |          |          |          |          |          |          |
| Production                      | 20,066.4 | 19,843.3 | 24,207.2 | 27,020.6 | 29,116.6 | 26,300.4 | 31,265.6 | 29,076.5 |
| Acres harvested                 | 680.1    | 732.3    | 866.3    | 937.3    | 1,126.7  | 1,064.0  | 1,050.7  | 960.9    |
| Yield per acre                  | 29.5     | 27.1     | 27.9     | 28.8     | 25.8     | 24.7     | 29.8     | 30.3     |
| <u>BEA 56: Terre Haute, IN</u>  |          |          |          |          |          |          |          |          |
| Production                      | 2,175.9  | 2,405.6  | 2,453.3  | 2,165.9  | 2,237.3  | 1,604.9  | 2,084.9  | 2,232.6  |
| Acres harvested                 | 79.4     | 76.0     | 77.7     | 75.0     | 81.7     | 71.4     | 65.2     | 59.7     |
| Yield per acre                  | 29.9     | 31.7     | 31.6     | 28.9     | 27.4     | 22.5     | 32.0     | 37.4     |
| <u>BEA 60: Indianapolis, IN</u> |          |          |          |          |          |          |          |          |
| Production                      | 19,107.3 | 16,336.6 | 18,145.2 | 17,145.3 | 21,926.3 | 16,167.1 | 19,021.6 | 18,860.2 |
| Acres harvested                 | 539.2    | 473.4    | 539.4    | 591.1    | 682.6    | 615.2    | 568.3    | 511.9    |
| Yield per acre                  | 35.4     | 34.2     | 33.6     | 28.9     | 32.1     | 26.3     | 33.5     | 36.8     |

(Continued)



Table 23. Continued

| BEA and BEA segment             | 1969     | 1970     | 1971     | 1972     | 1973     | 1974     | 1975     | 1976     |
|---------------------------------|----------|----------|----------|----------|----------|----------|----------|----------|
| <b>BEA 61: Anderson, IN</b>     |          |          |          |          |          |          |          |          |
| Production                      |          |          |          |          |          |          |          |          |
| Acres harvested                 | 2,274.3  | 2,147.8  | 2,463.5  | 2,676.9  | 3,558.3  | 2,823.7  | 2,867.1  | 2,518.9  |
| Yield per acre                  | 31.7     | 31.7     | 78.3     | 92.4     | 104.6    | 96.1     | 87.2     | 75.5     |
|                                 | 31.3     | 30.7     | 31.5     | 29.0     | 34.0     | 29.4     | 32.9     | 33.4     |
| <b>BEA 62: Indianapolis, IN</b> |          |          |          |          |          |          |          |          |
| Production                      |          |          |          |          |          |          |          |          |
| Acres harvested                 | 7,247.6  | 6,474.6  | 8,261.4  | 7,819.5  | 9,796.8  | 9,663.4  | 11,502.4 | 10,735.4 |
| Yield per acre                  | 32.0     | 31.6     | 28.3     | 320.6    | 370.1    | 353.8    | 362.7    | 323.4    |
|                                 | 31.9     | 30.6     | 31.0     | 24.4     | 26.5     | 27.3     | 31.4     | 33.2     |
| <b>BEA 63: Dayton, OH</b>       |          |          |          |          |          |          |          |          |
| Production                      |          |          |          |          |          |          |          |          |
| Acres harvested                 | 11,452.7 | 11,156.0 | 12,869.7 | 12,406.0 | 17,156.4 | 15,069.5 | 17,667.1 | 15,355.3 |
| Yield per acre                  | 34.6     | 36.7     | 378.3    | 467.2    | 561.5    | 502.2    | 485.3    | 447.5    |
|                                 | 35.0     | 36.9     | 34.0     | 26.6     | 30.6     | 30.0     | 36.4     | 34.3     |
| <b>BEA 64: Columbus, OH</b>     |          |          |          |          |          |          |          |          |
| Production                      |          |          |          |          |          |          |          |          |
| Acres harvested                 | 10,794.5 | 10,245.6 | 11,977.4 | 11,119.8 | 13,219.6 | 13,283.1 | 16,020.8 | 15,875.4 |
| Yield per acre                  | 64.1     | 39.4     | 373.8    | 436.5    | 505.9    | 460.2    | 460.8    | 433.7    |
|                                 | 33.1     | 33.7     | 32.3     | 25.5     | 26.1     | 28.9     | 34.8     | 36.6     |
| <b>BEA 114: St. Louis, MO</b>   |          |          |          |          |          |          |          |          |
| Production                      |          |          |          |          |          |          |          |          |
| Acres harvested                 | 3,400.9  | 4,092.2  | 5,177.9  | 7,264.5  | 6,425.1  | 5,500.8  | 7,386.8  | 7,152.6  |
| Yield per acre                  | 31.3     | 33.5     | 31.6     | 163.4    | 175.5    | 169.4    | 167.0    | 175.5    |
|                                 | 31.4     | 34.4     | 36.1     | 44.5     | 36.6     | 32.5     | 44.2     | 40.8     |
| <b>BEA 115: Fabouah, KY</b>     |          |          |          |          |          |          |          |          |
| Production                      |          |          |          |          |          |          |          |          |
| Acres harvested                 | 6,317.7  | 6,333.1  | 9,126.1  | 9,921.4  | 10,089.6 | 8,944.7  | 11,571.1 | 9,731.1  |
| Yield per acre                  | 29.4     | 247.8    | 303.3    | 377.9    | 417.0    | 399.9    | 642.7    | 395.5    |
|                                 | 27.1     | 25.4     | 30.1     | 26.0     | 24.2     | 22.4     | 18.0     | 24.6     |

Note: Individual items may not add to total due to rounding. Soybeans are soybeans for beans.

1. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.  
 2. BEA segment 61 is production, average harvested, and yield data for 1969 to 1974 from U.S. Department of Agriculture, Agricultural Statistics, 1975. Data for 1975 and 1976 from U.S. Department of Agriculture, Crop Production: 1977 Annual Summary.  
 3. BEA segment 114 is production, average harvested, and yield data for 1969 to 1974 from U.S. Department of Agriculture, Crop Production: 1977 Annual Summary.  
 4. BEA segment 115 is production, average harvested, and yield data for 1969 to 1974 from U.S. Department of Agriculture, Crop Production: 1977 Annual Summary.  
 5. BEA segment 115 is production, average harvested, and yield data for 1969 to 1974 from U.S. Department of Agriculture, Crop Production: 1977 Annual Summary.  
 6. BEA segment 115 is production, average harvested, and yield data for 1969 to 1974 from U.S. Department of Agriculture, Crop Production: 1977 Annual Summary.  
 7. BEA segment 115 is production, average harvested, and yield data for 1969 to 1974 from U.S. Department of Agriculture, Crop Production: 1977 Annual Summary.  
 8. BEA segment 115 is production, average harvested, and yield data for 1969 to 1974 from U.S. Department of Agriculture, Crop Production: 1977 Annual Summary.  
 9. BEA segment 115 is production, average harvested, and yield data for 1969 to 1974 from U.S. Department of Agriculture, Crop Production: 1977 Annual Summary.

A notable decline in production occurred in 1974 because of poor weather conditions. Despite greater acreage devoted to most crops, weather demonstrated its influence by holding many major crop yields at the lowest levels in a decade and resulted in larger than normal abandonment. Very late planting and replanting occurred because of extremely wet conditions in the spring, followed by hot and dry summer weather, an earlier than normal frost, and poor drying conditions at harvest.

Insect infestation and blight can dramatically affect production. In the corn blight year 1970, the U.S. average yield per acre dropped about 14 bushels below the trend line. Limitations put on the use of pesticides and herbicides have also affected yields. In this eight-year time frame, 1975 was a record production year in the United States and in the PSAs for most crops, major and minor.

#### B-2. Minor Grains

The U.S. production of oats, barley, and rye has generally decreased over time, while sorghum and rice production has increased (Table 24). As with corn, wheat, and soybeans, the minor crops are also included in U.S. set-aside programs and price-support programs. The 1978 feed grain acreage set-aside program requirement is 10 percent of the 1978 acreage planted to sorghum and barley. To qualify for target price payments on normal production, 1978 acreage must be reduced from 1977 plantings by 5 percent for sorghum and 20 percent for barley. Barley, sorghum, and rice are eligible for the loan rate system only.

The minor grains exhibited significant growth in output per acre from 1960 to 1977, specifically between 1960 and 1965 (Table 24). Barley yields, for example, increased from 31.0 bushels per acre to 42.9 between 1960 and 1965, and rice yields from 3,423 pounds per acre to 4,255, a 25 percent increase.

These crops, as are all crops, are affected by weather conditions. Dry weather, frost, drought, and low subsoil moisture can decrease production.

#### C. Feedstocks (Available Cropland)

Increasing national and world needs for agricultural products should result in more intense utilization of existing, and the conversion of land from other uses, to cropland. A recently completed study of non-federal land by the Soil Conservation Service (SCS) provides national and regional level data on (1) the potential for converting land in other use to cropland, (2) the extent of land that can be readily converted, (3) the problems related to developing this land for crop production, and (4) land use changes and trends. These data, and those provided by the various state Soil

Table 24. United States: Grain Production and Yields for Barley, Oats, Rice, Rye and Grain Sorghum, Selected Years, 1960-77  
(Thousands of bushels, bushels per harvested acre)

|      | Barley     |       | Oats       |       | Rice                    |                    | Rye        |       | Grain Sorghum |       |
|------|------------|-------|------------|-------|-------------------------|--------------------|------------|-------|---------------|-------|
|      | Production | Yield | Production | Yield | Production <sup>a</sup> | Yield <sup>b</sup> | Production | Yield | Production    | Yield |
| 1960 | 429,005    | 31.0  | 1,153,332  | 43.4  | 54,591                  | 3,423              | 33,108     | 19.6  | 619,594       | 39.7  |
| 1965 | 393,055    | 42.9  | 929,554    | 50.2  | 76,281                  | 4,255              | 33,307     | 22.6  | 672,698       | 51.6  |
| 1970 | 416,139    | 42.8  | 917,159    | 49.2  | 83,805                  | 4,618              | 36,840     | 25.8  | 683,571       | 50.4  |
| 1975 | 383,920    | 43.9  | 657,640    | 48.3  | 127,972                 | 4,567              | 17,875     | 22.0  | 760,069       | 49.0  |
| 1977 | 415,803    | 43.8  | 747,914    | 55.6  | 99,223                  | 4,412              | 16,998     | 24.5  | 790,647       | 56.2  |

a. Production in 1,000 cwt.

b. Yield in pounds per harvested acre.

Source: Data for 1960-75 from U.S. Department of Agriculture, Agricultural Statistics, 1977 ed. Data for 1977 from U.S. Department of Agriculture, Crop Reporting Board, Crop Production, 1977 Annual Summary: Acreage, Yield, and Production, 1978.

and Conservation Needs Inventory Committees, serve as an analytical base for evaluating historical and future ORS hinterland land use. Land, more specifically land that is potential cropland, provides the basis for future increases in grain production. The inventory of land "suitable" as cropland acts as a constraint to increases in future grain production.

Within this century, scientific and technological developments, and resulting increases in crop and livestock production, have greatly altered the farm sector's land use pattern. Developments leading to low cost nitrogenous fertilizer production, herbicides, and pesticides have facilitated major shifts in cropping systems by limiting crop rotations and greatly increasing areas of intertilled crops with little or no meadow crops. Improvements in farm mechanization have greatly affected agricultural land requirements as the combustion engine displaced draft animals and so released for the production of crop and livestock for market approximately 50 million acres of cropland devoted to feeding these animals.

Increases in the production, size, and performance of crop and livestock machinery, especially equipment associated with crop production and harvesting, contributed significantly to changes in land use. Mechanization favored those parts of the hinterland and the United States having large expanses of level to mildly rolling land, and penalized predominantly rolling to hilly land. Technological developments in automotive transportation and highway systems resulted in high density and vertical urban growth patterns and increased access and speed in serving more distant markets.

In many important agricultural sections of the United States, and in the ORS hinterland, the area of land in farms has been decreasing rapidly during recent decades, while large increases have occurred in non-farm uses of land. Dramatic changes occurred in national level land use between 1967 and 1975, with a net loss

to cropland of 30.5 million acres. About 60 percent of the 17 million acres converted to urban and built-up areas was land in capability classes I-III. (This is land classified as potential cropland, with some soils having moderate to severe limitations that reduce plant choice or require conservation practices.) Nearly 7 million acres were converted to water during the same period.

As new cropland is needed, most will be gained from pasture and range and most will require the implementation of conservation practices. The opportunities to gain new cropland without commitments to conservation are already limited in nearly all the crop production regions. The Corn Belt, Delta, Appalachian, and Southeast regions (which include the PSAs in the ORS hinterland) have more options than the Nation as a whole for converting land to cropland. Of land presently in other uses in these four regions, 37.8 million acres are estimated to have a high potential for conversion to cropland. Erosion and wetness are the most serious problems facing these regions. These and other problems (such as soil, climate, ownership, commodity prices, and production and development costs) affect the likelihood that conversion to cropland from present land uses will occur in the foreseeable future.

As land suitable as cropland is used or is adapted to non-farm uses, the margin of suitable land available to be brought into grain production narrows. Any methodology that projects grain production must, therefore, include a cropland availability constraint. Such a constraint was incorporated at two levels in the projections of grain production in the PSAs. The state level projections of the USDA include a cropland availability constraint, as did the disaggregate PSA production projections.

As shown in Table 25, a relatively large percentage of the total land area in the ORS hinterland was farmland in 1974, approximately 44.1 million acres, or 53 percent, of a total land area of 83.4 million acres. Of this total farmland, 28.0 million acres, or 64 percent, was cropland. Of the 28.0 million area of total cropland, 16.3 million acres, over 58 percent, were harvested as grain; 10 million acres were pasture, and 1.8 million acres were either idle, in summer fallow, were cropland on which all crops failed, or were cropland used for soil improvement crops.

Land was most intensively farmed in those PSAs located in the major grain producing states of Ohio, Illinois, and Indiana [i.e., BEAs 53 (Lexington), 55 (Evansville), 56 (Terre Haute), 60 (Indianapolis), 61 (Anderson), 62 (Cincinnati), 63 (Dayton), and

Table 25. Ohio River Basin: Land Area and Farm and Nonfarm Utilization,  
by BEAs or BEA Segments, a 1974

(Thousands of acres unless otherwise specified)

| BEA and BEA segment      | Total<br>land area | Farmland       |                               |                   |                       |         |          |          |         |          | Other<br>farmland | Nonfarmland |
|--------------------------|--------------------|----------------|-------------------------------|-------------------|-----------------------|---------|----------|----------|---------|----------|-------------------|-------------|
|                          |                    | Total farmland |                               | Cropland          |                       |         |          | Other    |         |          |                   |             |
|                          |                    | Amount         | As a percent<br>of total land | Total<br>cropland | Cropland<br>harvested | Pasture | Cropland | Woodland | Other   |          |                   |             |
| Primary Study Areas      | 83,415.4           | 44,064.3       | 52.8                          | 27,988.6          | 16,270.5              | 9,962.8 | 1,755.3  | 9,296.0  | 6,779.7 | 39,411.0 |                   |             |
| BEA 44: Atlanta, GA      | 5,177.0            | 1,213.8        | 23.5                          | 502.9             | 168.5                 | 295.8   | 38.6     | 471.5    | 239.4   | 3,963.1  |                   |             |
| BEA 45: Birmingham, AL   | 8,116.6            | 2,493.9        | 30.7                          | 1,193.7           | 603.2                 | 496.5   | 94.0     | 809.7    | 490.5   | 5,622.7  |                   |             |
| BEA 46: Memphis, TN      | 2,134.5            | 1,245.4        | 58.4                          | 721.2             | 424.6                 | 225.7   | 70.9     | 339.3    | 184.9   | 889.1    |                   |             |
| BEA 47: Huntsville, AL   | 5,767.1            | 2,842.2        | 49.3                          | 1,629.0           | 908.3                 | 614.5   | 106.3    | 730.7    | 482.5   | 2,924.8  |                   |             |
| BEA 48: Chattanooga, TN  | 4,972.0            | 1,653.5        | 33.3                          | 839.1             | 385.6                 | 406.5   | 47.0     | 566.6    | 247.8   | 3,318.4  |                   |             |
| BEA 49: Nashville, TN    | 12,400.1           | 7,233.4        | 57.8                          | 4,165.5           | 1,635.8               | 2,251.3 | 278.4    | 1,963.1  | 1,078.8 | 5,226.8  |                   |             |
| BEA 50: Knoxville, TN    | 4,314.3            | 1,230.6        | 28.5                          | 671.9             | 230.3                 | 403.8   | 37.8     | 381.7    | 176.9   | 3,083.7  |                   |             |
| BEA 52: Huntington, WV   | 2,455.7            | 852.2          | 34.7                          | 343.6             | 127.3                 | 181.4   | 34.9     | 317.9    | 190.7   | 1,603.5  |                   |             |
| BEA 53: Lexington, KY    | 3,843.8            | 3,109.8        | 80.9                          | 2,023.8           | 588.9                 | 1,324.0 | 110.8    | 483.9    | 602.1   | 734.0    |                   |             |
| BEA 54: Louisville, KY   | 5,403.0            | 3,546.2        | 65.6                          | 2,203.6           | 974.2                 | 1,063.0 | 166.4    | 762.3    | 582.4   | 1,856.8  |                   |             |
| BEA 55: Evansville, IN   | 6,942.7            | 4,668.4        | 67.2                          | 3,518.6           | 2,677.7               | 622.9   | 218.0    | 608.9    | 540.9   | 2,274.3  |                   |             |
| BEA 56: Terre Haute, IN  | 643.8              | 409.4          | 63.6                          | 301.4             | 232.9                 | 44.6    | 23.9     | 54.6     | 53.4    | 234.4    |                   |             |
| BEA 60: Indianapolis, IN | 4,047.3            | 2,629.9        | 65.0                          | 2,044.4           | 1,730.5               | 242.9   | 71.0     | 295.8    | 289.7   | 1,417.4  |                   |             |
| BEA 61: Anderson, IN     | 514.9              | 408.0          | 79.2                          | 331.3             | 280.5                 | 40.1    | 10.7     | 35.2     | 41.5    | 106.9    |                   |             |
| BEA 62: Cincinnati, OH   | 5,553.1            | 3,670.6        | 66.1                          | 2,351.5           | 1,277.7               | 879.4   | 194.4    | 651.3    | 667.7   | 1,882.6  |                   |             |
| BEA 63: Dayton, OH       | 2,575.6            | 2,023.2        | 78.6                          | 1,669.8           | 1,473.1               | 147.4   | 49.3     | 149.8    | 203.6   | 552.4    |                   |             |
| BEA 64: Columbus, OH     | 4,891.2            | 2,574.2        | 52.6                          | 1,778.3           | 1,360.7               | 330.1   | 87.5     | 373.3    | 442.6   | 2,317.0  |                   |             |
| BEA 114: St. Louis, MO   | 1,102.7            | 769.5          | 69.8                          | 631.5             | 499.3                 | 86.1    | 46.1     | 59.2     | 78.9    | 333.2    |                   |             |
| BEA 115: Paducah, KY     | 2,560.0            | 1,490.1        | 58.2                          | 1,067.5           | 691.4                 | 306.8   | 69.3     | 217.2    | 205.4   | 1,070.0  |                   |             |

Note: Individual items may not add to total due to rounding. Data assembled on a county level and aggregated into BEAs and BEA segments. Nonfarmland derived by subtracting total farmland from total land area.

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

b. Includes cropland used for soil improvement crops, cropland on which all crops failed, land in cultivated summer fallow, and idle cropland.

c. Includes pastureland and rangeland other than cropland and woodland pasture; and land in house lots, barn lots, ponds, roads, wastelands, etc.

d. Includes pasture, range, wood and forestlands not in farms; urban, industrial and nonfarm residential areas; parks and wildlife refuges, military lands; and roads, railroads and miscellaneous other areas.

Source: Data for total land area from Table 26. All other information from U.S. Department of Commerce, Bureau of the Census, Census of Agriculture, 1974, for the States of Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio and Tennessee.

114 (St. Louis)]. In these PSAs, farmland, as a percentage of total land, represented between 64 to 81 percent. Furthermore, a large percentage of the farmland was cropland, and a significant area of that cropland was harvested.

The margin of land available and suitable for cropland in an area already so intensively farmed is of concern. A constraint was estimated to ensure that the area required to be harvested, to meet projections of production, would not exceed the area suitable for harvesting.

The land suitable as cropland was estimated by aggregating county level data, on the classes and subclasses of land considered suitable as cropland, into PSAs. For purposes of this study, land capability classes and subclasses I, IIe, IIw, IIle, and IIlw were selected and summed to define land suitable as cropland in any one county. Soils in class I have few limitations that restrict their use. Soils in class II have some limitations that reduce the choice of plants or require moderate conservation practices or both. Soils in class III have severe limitations that reduce the choice of plants or require special conservation practices or both. Subclass "e" is made up of soils where the susceptibility to erosion is the dominant problem or hazard in their use. Subclass "w" is made up of soils where excess water is the dominant hazard or limitation in their use (see Appendix for detailed definition).

Following the above procedure, an estimated 44 percent, or 36.9 million acres, of the total land area of the ORS hinterland was determined suitable as cropland (Table 26). This 36.9 million acres of land suitable as cropland, relative to 16.3 million acres that were harvested in the hinterland in 1974, indicate that in spite of the existing high level of cropland utilization in the PSAs, there still remains a great deal of unused suitable cropland. An estimated 56 percent, or 20.7 million acres, of the total land area of the hinterland was suitable as cropland but was not used as cropland in 1974. The greatest margin of unused land suitable as cropland was in the southeastern PSAs where between approximately 55 and 90 percent of the land suitable as cropland was not harvested as of 1974 [i.e., BEAs 44 (Atlanta), 45 (Birmingham), 46 (Memphis), 47 (Huntsville), 48 (Chattanooga), 49 (Nashville), 50 (Knoxville), 52 (Huntington), 53 (Lexington), 54 (Louisville) and 115 (Paducah)].

With one exception, projected acres by PSA segment met the land suitability constraint within safe margins. Projected acres harvested in BEA 60 (Indianapolis), an already intensively farmed

Table 26. Ohio River Basin: Total Land Area, Land Suitable as Cropland, Cropland Harvested and Remaining Land Suitable for Crops, by BEAs or BEA Segments, a 1974

(Thousands of acres unless otherwise specified)

| BEA and BEA segment        | Total land area | Land suitable as cropland <sup>b</sup> |                                 | Cropland harvested |                                     | Remaining land suitable |                                     |
|----------------------------|-----------------|--|---------------------------------|--------------------|-------------------------------------|-------------------------|-------------------------------------|
|                            |                 | Amount                                 | As a percent of total land area | Amount             | As a percent of total land suitable | Amount                  | As a percent of total land suitable |
| <b>Primary Study Areas</b> | <b>83,415.4</b> | <b>36,921.6</b>                        | <b>44.3</b>                     | <b>16,270.5</b>    | <b>44.1</b>                         | <b>20,651.3</b>         | <b>55.9</b>                         |
| BEA 44: Atlanta, GA        | 5,177.0         | 1,493.4                                | 28.8                            | 168.5              | 11.3                                | 1,324.9                 | 88.7                                |
| BEA 45: Birmingham, AL     | 8,116.6         | 2,548.4                                | 31.4                            | 603.2              | 23.7                                | 1,945.2                 | 76.3                                |
| BEA 46: Memphis, TN        | 2,134.5         | 951.7                                  | 44.6                            | 424.6              | 44.6                                | 527.1                   | 55.4                                |
| BEA 47: Huntsville, AL     | 5,767.1         | 2,653.7                                | 46.0                            | 908.3              | 34.2                                | 1,745.4                 | 65.8                                |
| BEA 48: Chattanooga, TN    | 4,972.0         | 1,725.9                                | 34.7                            | 385.6              | 22.3                                | 1,340.3                 | 77.7                                |
| BEA 49: Nashville, TN      | 12,400.1        | 4,991.0                                | 40.2                            | 1,635.8            | 32.8                                | 3,355.2                 | 67.2                                |
| BEA 50: Knoxville, TN      | 4,314.3         | 999.2                                  | 23.2                            | 230.3              | 23.0                                | 768.9                   | 77.0                                |
| BEA 52: Huntington, WV     | 2,455.7         | 383.8                                  | 15.6                            | 127.3              | 33.2                                | 256.5                   | 66.8                                |
| BEA 53: Lexington, KY      | 1,843.8         | 1,778.5                                | 46.3                            | 588.9              | 33.1                                | 1,189.6                 | 66.9                                |
| BEA 54: Louisville, KY     | 5,403.0         | 2,393.3                                | 44.3                            | 974.2              | 40.7                                | 1,419.1                 | 59.3                                |
| BEA 55: Evansville, IN     | 6,942.7         | 4,329.6                                | 62.4                            | 2,677.7            | 61.8                                | 1,651.9                 | 38.2                                |
| BEA 56: Terre Haute, IN    | 643.8           | 384.8                                  | 59.8                            | 232.9              | 60.5                                | 152.0                   | 39.5                                |
| BEA 60: Indianapolis, IN   | 4,047.3         | 2,705.2                                | 66.8                            | 1,730.5            | 64.0                                | 974.7                   | 36.0                                |
| BEA 61: Anderson, IN       | 514.9           | 378.9                                  | 73.6                            | 280.5              | 74.0                                | 98.4                    | 26.0                                |
| BEA 62: Cincinnati, OH     | 3,553.1         | 2,453.6                                | 44.2                            | 1,277.7            | 52.1                                | 1,175.9                 | 47.9                                |
| BEA 63: Dayton, OH         | 2,575.6         | 2,084.5                                | 80.9                            | 1,473.1            | 70.7                                | 611.4                   | 29.3                                |
| BEA 64: Columbus, OH       | 4,891.2         | 2,380.1                                | 48.7                            | 1,360.7            | 57.2                                | 1,019.5                 | 42.8                                |
| BEA 114: St. Louis, MO     | 1,102.7         | 830.6                                  | 75.3                            | 499.3              | 60.1                                | 331.3                   | 39.9                                |
| BEA 115: Paducah, KY       | 2,560.0         | 1,455.5                                | 56.9                            | 691.4              | 47.5                                | 764.1                   | 52.5                                |

Note: Individual items may not add to total due to rounding. Data assembled on a county level and aggregated into BEAs and BEA segments.

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

b. Includes land capability classes and subclasses I, IIe, IIw, IIIe and IIIw as measured in 1967.

Source: Total land area and land suitable as cropland tabulated from the soil and water conservation needs inventories conducted for the year 1967 by the State Soil and Conservation Needs Inventory Committees of the states of Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio and Tennessee. Cropland harvested tabulated from the U.S. Department of Commerce, Bureau of the Census, Census of Agriculture, 1974 ed.



area, equalled the land area judged suitable as cropland. However, no adjustment to BEA 60's projected production was deemed necessary. One might find that as an area approached full utilization of suitable cropland that growth in production would be slower than projected or that land previously judged unsuitable would be brought into production.

#### D. Existing Production Levels

Grain production in the Ohio River System hinterland is characterized by intensive utilization of cropland, increasing acres harvested of all acres planted, and higher yields per acre. National and ORS hinterland crop production, in general, experienced strong growth between 1969 and 1976.

##### D-1. Corn, Wheat, and Soybeans

Ohio River System hinterland production of corn, wheat, and soybeans, the most important waterborne grains, increased steadily between 1969-76. Almost 16 million tons of grain were produced in the ORS hinterland in 1969, increasing to 25.6 million tons in 1976. The increase represents an annual growth of 7 percent (Table 27). In the ORS hinterland as a whole, production was concentrated in five PSAs, all of which include areas in the highly agricultural states of Ohio, Illinois, Indiana, and Kentucky. BEAs 55 (Evansville), 60 (Indianapolis), 62 (Cincinnati), 63 (Dayton), and 64 (Columbus) represented between 65 to 70 percent of total hinterland grain production during 1969-76. Although these PSAs exhibited strong growth in production between 1969-76, the greatest increase occurred in the southeastern PSAs: BEAs 47 (Huntsville), 48 (Chattanooga), 49 (Nashville), 50 (Knoxville), and 115 (Paducah). Between 1969-76, grain production increased in each of the 19 PSAs in the ORS hinterland without exception.

Production of three major crops in the ORS hinterland increased at a faster rate than U.S. production during the 1969-76 period (Table 27). Hinterland production, as a percentage of total U.S. grain production of corn, wheat, and soybeans, increased from 7.7 percent, or 16 million of 208.6 million tons in 1969, to 9.2 percent, or 25.6 million of 278.5 million tons in 1976.

Corn accounted for almost three-fourths of the hinterland's 1976 total production of all three crops. The predominance of corn, relative to wheat and soybeans, was also displayed in the PSAs' grain consumption and waterborne shipments. As indicated

Table 27. United States and Ohio River Basin: Production of Grains,<sup>a</sup>  
by BEAs or BEA Segments,<sup>b</sup> Estimated 1969-76  
(Thousands of tons unless otherwise specified)

| BEA and BEA segment      | 1969      | 1970      | 1971      | 1972      | 1973      | 1974      | 1975      | 1976      | Average annual<br>percentage change,<br>1969-76 |
|--------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|---|
| United States            | 208,641.1 | 190,734.9 | 241,911.6 | 240,667.0 | 255,841.4 | 221,053.9 | 273,481.7 | 278,529.0 | 4.2   |
| Primary Study Areas      | 15,964.3  | 12,785.6  | 18,653.7  | 17,817.5  | 17,927.0  | 17,862.1  | 20,699.6  | 25,576.9  | 7.0   |
| BEA 44: Atlanta, GA      | 48.3      | 33.5      | 52.1      | 49.8      | 53.8      | 72.9      | 90.5      | 87.7      | 8.9   |
| BEA 45: Birmingham, AL   | 244.5     | 206.3     | 264.8     | 237.4     | 278.8     | 286.5     | 385.7     | 418.0     | 8.0   |
| BEA 46: Memphis, TN      | 269.7     | 240.7     | 356.8     | 340.8     | 325.7     | 337.3     | 426.3     | 483.1     | 8.7   |
| BEA 47: Huntsville, AL   | 320.4     | 290.4     | 430.2     | 368.7     | 405.3     | 449.6     | 616.4     | 643.1     | 10.5  |
| BEA 48: Chattanooga, TN  | 159.3     | 122.7     | 203.6     | 212.8     | 237.2     | 234.1     | 285.7     | 378.4     | 13.2  |
| BEA 49: Nashville, TN    | 841.6     | 703.2     | 1,148.4   | 1,145.8   | 1,203.6   | 1,306.5   | 1,316.5   | 1,949.8   | 12.8  |
| BEA 50: Knoxville, TN    | 56.9      | 51.1      | 70.4      | 78.3      | 93.5      | 79.9      | 87.0      | 118.0     | 11.0  |
| BEA 51: Huntington, WV   | 73.4      | 49.1      | 81.6      | 77.7      | 81.6      | 86.8      | 97.0      | 105.4     | 5.3   |
| BEA 52: Lexington, KY    | 244.9     | 192.8     | 341.1     | 332.2     | 341.8     | 357.8     | 313.5     | 427.4     | 8.3   |
| BEA 53: Louisville, KY   | 685.0     | 475.9     | 813.4     | 810.0     | 869.3     | 929.8     | 826.6     | 1,173.7   | 8.0   |
| BEA 54: Evansville, IN   | 3,675.7   | 2,458.2   | 3,971.5   | 4,127.3   | 3,937.5   | 3,881.5   | 4,649.1   | 5,594.6   | 6.2   |
| BEA 55: Terre Haute, IN  | 329.0     | 298.4     | 408.7     | 361.2     | 404.7     | 288.0     | 427.1     | 498.1     | 6.1   |
| BEA 56: Indianapolis, IN | 2,932.0   | 2,357.3   | 3,209.7   | 3,050.5   | 3,283.4   | 2,609.1   | 3,097.3   | 3,996.0   | 4.5   |
| BEA 61: Anderson, IN     | 389.2     | 327.5     | 423.9     | 385.4     | 430.6     | 409.4     | 452.4     | 600.7     | 6.4   |
| BEA 62: Cincinnati, OH   | 1,402.4   | 1,100.8   | 1,566.5   | 1,389.5   | 1,416.2   | 1,513.5   | 1,630.3   | 2,036.6   | 5.5   |
| BEA 63: Dayton, OH       | 1,849.3   | 1,773.5   | 2,341.2   | 2,061.5   | 2,000.5   | 2,194.5   | 2,581.3   | 2,845.0   | 6.4   |
| BEA 64: Columbus, OH     | 1,542.5   | 1,390.9   | 1,798.8   | 1,595.4   | 1,505.8   | 1,794.3   | 1,979.6   | 2,446.7   | 6.8   |
| BEA 114: St. Louis, MO   | 397.8     | 332.6     | 495.2     | 578.8     | 454.4     | 397.3     | 620.9     | 672.1     | 7.8   |
| BEA 115: Paducah, KY     | 502.4     | 380.6     | 675.9     | 614.3     | 599.0     | 633.4     | 816.5     | 1,100.5   | 11.9  |

Note: Individual items may not add to total due to rounding. Data assembled on a county level and aggregated into BEAs and BEA segments.

a. Total production of corn, wheat, and soybeans only. Corn is corn for grain. Wheat is all wheat. Soybeans are soybeans for beans.

b. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.  
Source: Total U.S. production for 1969 to 1974 from U.S. Department of Agriculture, Agricultural Statistics, 1977 and 1978 eds.; data for 1975 and 1976 from U.S. Department of Agriculture, Crop Production: 1977 Annual Summary; Acreage, Yield and Production, January 1978. BEA and BEA segment level data, estimated from production data provided annually for 1969-76 by the U.S. Department of Agriculture Crop Reporting Services of the states of Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio and Tennessee.

earlier, corn yields almost three times as many bushels per harvested acre as wheat or soybeans. Corn production, as a percentage of the production of all three, varied from 36.6 to 93.9 percent of any one PSA's total production in 1976. Corn production as a percentage of the total was lowest in the southeastern PSAs in Georgia and Alabama, where soybeans were the preferred crop. Of the three principal crops, corn represented a greater percentage share of total grain production in the ORS hinterland in 1976 (73.5 percent) than did corn in terms of U.S. production (63.0 percent) (Table 28). In 1976, the PSAs produced 10.7 percent of the corn grown for grain in the United States.

Wheat is not as important a crop in the PSAs as it is in the United States in general. Wheat represented only 8 percent of total grain production in the hinterland in 1976; however, it represented 23 percent of U.S. production. In the ORS hinterland as a whole, wheat is grown in the largest quantities in Ohio, Illinois, and Indiana. However, in the southeastern PSAs, wheat, in many cases, represented a larger percentage share of total production. The hinterland produced only 3.2 percent of all wheat grown in the United States in 1976.

Soybeans represented a larger percentage share of total production in the PSAs (18.4 percent) in 1976 than they did for the Nation as a whole (13.9 percent). The percent that soybean production represented of total production of grain in the PSAs in 1976 varied widely, ranging from 2.5 percent in BEA 52 (Huntington) to 61.7 percent in BEA 45 (Birmingham). In 1976, soybean production in the PSAs represented 12.2 percent of U.S. production of soybeans for beans (Table 28).

#### D-2. Minor Grains

The production of barley, oats, rice, rye, and sorghum in the PSAs and in the United States is secondary to the production of corn, wheat, and soybeans. Production of these minor grains in 1976 is shown in Table 29. Production of barley, sorghum, and rice in the hinterland was and is a relatively small share of total U.S. production.

The production of oats and rye in those states that include areas of the Ohio River System hinterland represented 12.3 percent and 19.8 percent of total U.S. production of these grains in 1976, respectively. Most of the oats and rye produced in these states was either consumed on the farm where produced or was trucked for

Table 28. United States and Ohio River Basin: Production of Grains, by Types of Grains, and by BEAs or BEA Segments, a Estimated 1976

(Thousands of tons unless otherwise specified)

| BEA and BEA Segment      | Totalb    |         | Corn      |                       | Wheat    |                       | Soybeans |                       |
|--------------------------|-----------|---------|-----------|-----------------------|----------|-----------------------|----------|-----------------------|
|                          | Amount    | Percent | Amount    | As a percent of total | Amount   | As a percent of total | Amount   | As a percent of total |
| United States            | 278,529.0 | 100     | 175,528.3 | 63.0                  | 64,335.2 | 23.1                  | 38,665.5 | 13.9                  |
| Primary Study Areas      | 25,576.9  | 100     | 18,802.6  | 73.5                  | 2,076.1  | 8.1                   | 4,698.1  | 18.4                  |
| BEA 44: Atlanta, GA      | 87.7      | 100     | 41.1      | 46.9                  | 9.8      | 11.1                  | 36.8     | 42.0                  |
| BEA 45: Birmingham, AL   | 418.0     | 100     | 152.8     | 36.6                  | 7.3      | 1.7                   | 257.9    | 61.7                  |
| BEA 46: Memphis, TN      | 493.1     | 100     | 241.3     | 48.2                  | 33.0     | 6.8                   | 168.8    | 34.9                  |
| BEA 47: Huntsville, AL   | 643.1     | 100     | 272.6     | 42.4                  | 47.7     | 7.4                   | 322.7    | 50.2                  |
| BEA 48: Chattanooga, TN  | 378.4     | 100     | 300.5     | 79.4                  | 12.5     | 3.3                   | 65.3     | 17.3                  |
| BEA 49: Nashville, TN    | 1,949.8   | 100     | 1,373.0   | 70.4                  | 207.7    | 10.7                  | 369.1    | 18.9                  |
| BEA 50: Knoxville, TN    | 118.0     | 100     | 96.7      | 81.9                  | 13.3     | 11.3                  | 8.0      | 6.8                   |
| BEA 52: Huntington, WV   | 105.4     | 100     | 91.5      | 86.8                  | 3.3      | 3.1                   | 10.6     | 10.1                  |
| BEA 53: Lexington, KY    | 427.4     | 100     | 401.1     | 93.9                  | 15.8     | 3.7                   | 10.5     | 2.5                   |
| BEA 54: Louisville, KY   | 1,173.7   | 100     | 1,009.3   | 86.0                  | 65.6     | 5.6                   | 98.8     | 8.4                   |
| BEA 55: Evansville, IN   | 5,594.6   | 100     | 4,234.8   | 76.8                  | 426.6    | 7.6                   | 873.2    | 15.6                  |
| BEA 56: Terre Haute, IN  | 498.1     | 100     | 386.4     | 78.0                  | 42.6     | 8.6                   | 67.0     | 13.5                  |
| BEA 61: Indianapolis, IN | 3,998.0   | 100     | 3,190.4   | 79.8                  | 241.2    | 6.0                   | 566.4    | 14.2                  |
| BEA 62: Cincinnati, OH   | 690.7     | 100     | 485.7     | 70.9                  | 39.4     | 6.6                   | 75.6     | 12.6                  |
| BEA 63: Dayton, OH       | 2,036.6   | 100     | 1,563.5   | 76.8                  | 150.7    | 7.4                   | 322.4    | 15.8                  |
| BEA 64: Columbus, OH     | 2,845.0   | 100     | 2,075.0   | 72.9                  | 308.9    | 10.9                  | 461.1    | 16.2                  |
| BEA 114: St. Louis, MO   | 2,446.7   | 100     | 1,724.2   | 70.5                  | 245.8    | 10.0                  | 476.7    | 19.5                  |
| BEA 115: Paducah, KY     | 672.1     | 100     | 335.8     | 50.0                  | 121.5    | 18.1                  | 214.8    | 31.9                  |
|                          | 1,100.5   | 100     | 724.7     | 65.8                  | 83.6     | 7.6                   | 292.2    | 26.5                  |

Note: Individual items may not add to total due to rounding. Data assembled on a county level and aggregated into BEAs and BEA segments.

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.  
b. Total production of corn, wheat and soybeans only. Corn is corn for grain. Wheat is all wheat. Soybeans are soybeans for beans.

Source: Total U.S. production data from U.S. Department of Agriculture, Crop Production: 1977 Annual Summary; Acreage, Yield and Production, January 1978. BEA and BEA segment data estimated from production data provided annually for 1969-76 by the U.S. Department of Agriculture Crop Reporting Services of the states of Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio and Tennessee.

Table 29. United States and Ohio River System Hinterland<sup>a</sup>: Production of Minor Grains, b 1976  
(Thousands of tons unless otherwise specified)

|                                    | Barley  | Oats    | Rice                 | Rye <sup>c</sup> | Grain Sorghum |
|------------------------------------|---------|---------|----------------------|------------------|---------------|
| United States                      | 8,931.9 | 8,741.0 | 115,648.0            | 418.8            | 20,162.9      |
| Ohio River System hinterland       | 70.8    | 1,075.9 | 6,048.0 <sup>d</sup> | 82.9             | 359.2         |
| As a percentage of U.S. production | 0.8     | 12.3    | 5.2                  | 19.8             | 1.8           |

a. The States of Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio and Tennessee.  
b. Barley, oats, rice, rye and sorghum for grain.  
c. Production in thousands of cwt.  
d. Mississippi only.

Source: U.S. Department of Agriculture, Crop Production: 1977 Annual Summary; Acreage, Yield and Production, January 1978.

consumption in contiguous states. These grains have not and are not expected to move in great quantities by either rail or water.

United States production of barley has been and will remain concentrated in North Dakota, California, Montana, Minnesota, Idaho, and South Dakota; oat production in Minnesota, Iowa, Wisconsin, and North and South Dakota; rice production in Arkansas, Texas, California, and Louisiana; rye production in Minnesota, North and South Dakota, Georgia, and Nebraska; and grain sorghum production in Texas, Kansas, and Nebraska.

#### E. Forecasting Procedures and Assumptions

Regional level projections of grain production that correspond to the Ohio River System hinterland do not exist. Grain production projections for the states that contain PSAs of the ORS hinterland exist but were found to be inadequate in that the time frames, assumptions, and base data did not correspond.

In general, projections of grain production have been based on disaggregations of USDA national projections. The methods used in disaggregating the USDA projections are presented below.

##### E-1. U.S. Department of Agriculture: National - Interregional Agricultural Projections System (NIRAP)

The state level projections generated by the USDA NIRAP system for 1985, 1990, and 2000 were used as the base for grain production projections for the PSAs. The baseline scenario was chosen. The assumptions and constraints that underlie this model are the same for the grain production projections as they were for projecting livestock production (grain consumption). The system takes account of the presence and interaction of such variables as commodity production, land use, soil erosion, crop yield, and energy and irrigation water requirements. Elasticities of price and demand by commodity are included. The model's demand and supply attributes and macro-economic assumptions are as outlined in Table 18.

The state and commodity level production projections generated by the NIRAP system provide a consistent and comparative set of projections for the years 1985, 1990, and 2000. State production of corn, wheat, and soybeans for 1980 was estimated by interpolating backwards the annual growth trend line of the 1974-76 base to 1985.

E-2. Disaggregation of State  
Level Data to BEA Level

For the period 1969-76, the amount of corn, wheat, and soybeans produced in each PSA was identified and divided by the respective state total to derive a percentage share produced of each of the three crops in each of the 19 PSAs. A linear regression analysis, in conjunction with expert judgment, was used to project these percentage shares for each PSA to the year 1980, 1990, and 2000. These projected percentage shares were multiplied by the USDA projected state totals of grain production by commodity for 1980, 1990, and 2000. Thus, USDA projections of corn, wheat, and soybean production were allocated to each PSA.

For corn and wheat, for each PSA, the difference between grain production for the 1974-76 average and grain production in 2000 was allocated to 2040. Thus, the rate of increase between 2000 and 2040 is the same as the rate of increase between the 1974-76 average and 2000. This assumption was based on the conclusion by many economists that USDA has conservatively estimated corn and wheat production for 2000.

For soybeans, for each PSA the difference between the 1974-76 average grain production level and that in the year 2000 was divided by three. This amount was allocated to 2040. This rate of increase between 2000 and 2040 is one-third of the rate of increase that is expected to occur in any one PSA between the base year average and 2000. This assumption is based on the conclusion by many economists that USDA has liberally estimated soybean production to the year 2000.

For each of the three crops, the projected production of each, by PSA, was summed to estimate total grain production by PSA for each of the five projection years.

Acres harvested by crop were estimated for the period 1980 to 2040 by dividing production for each of the PSAs by the yield per harvested acre as estimated by USDA. For all PSAs, the total acres

---

1. A basic assumption underlying the crop yield projections is that the rapid increase in agricultural productivity that occurred during 1950-74 will continue in 1975-85 but at a slower rate of increase. National average crop yield projections for the major crops in 1985 show the following increases over the 1972-74 averages: wheat - 24 percent, corn - 34 percent, soybeans - 15 percent. In total, yield projections are generally consistent

in grain were less than or equal to the estimated number of acres available for grain production. Projected grain production levels, yields, and acres planted are necessarily based on well-defined sets of assumptions. Included in these assumptions are propositions underlying weather conditions, world economic and political realities, and changes in technologies. Changes in any one assumption such as weather will alter grain production levels for a specific year from projected levels. Changes in political or economic world conditions could alter production levels from expected outcomes for a period of years. All grain production data are estimated on a tenuous base, and grain production levels in 2000 or 2040 could vary from these levels projected by USDA and other agricultural economists.

#### F. Probable Future Production Levels

The application of the above methodology yields an estimated average increase of total grain production for the PSAs of 1.01 percent between 1976 and 2000. By 1980, grain production in the hinterland is expected to decrease over 20 percent, dropping from the 1976 level of 25.6 million tons to 19.9 million tons (Table 30). This decline in production is a function of expected decreases in the production of corn, which yields almost three times as much grain by weight per harvested acre as soybeans and wheat. Corn production is expected to decrease in each of the eight states which encompass the PSAs, most notably in Kentucky and Tennessee. Those PSAs in which corn represented the largest percentage share of the total aggregate production of all three principal crops in

---

with a 1.0 to 1.5 percent annual increase in agricultural productivity and moderate increases in yield -- increasing inputs such as chemical fertilizers. Crop yield projections used in the NIRAP system are the same as those used in the 1972 OBERS projections of regional economic activity in the U.S. See U.S. Department of Agriculture, Economic Research Service, USDA National - Interregional Agricultural Projections (NIRAP) System, July 1978.

1. Some of these assumptions include: no major wars; no major disruption in the world economy; historical trends in environmental relationships and controls; and historical patterns and trends in consumer tastes and preferences. See U.S. Department of Agriculture, Economic Research Service, USDA National - Interregional Agricultural Projections (NIRAP) System, July 1978.



<sup>a</sup> Values are means ± SD; <sup>b</sup> values are means ± SEM.

| FHA and GSA account        | Estimated 1976 | Projected |          |          |          | Average annual percentage change |           |
|----------------------------|----------------|-----------|----------|----------|----------|----------------------------------|-----------|
|                            |                | 1980      | 1990     | 2000     | 2010     | 1976-79--2010                    | 2000-2010 |
| <b>Primary Study Areas</b> | 25,576.9       | 10,859.7  | 25,199.4 | 32,549.6 | 30,361.2 | 46,719.5                         | 1.01      |
| SEA 43: Atlanta, GA        | 92.7           | 113.3     | 154.5    | 270.5    | 328.8    | 392.6                            | 4.80      |
| SEA 45: Bureau Beach, AL   | 458.0          | 423.4     | 637.0    | 905.5    | 1,049.8  | 1,201.4                          | 3.27      |
| SEA 47: Memphis, TN        | 443.1          | 477.8     | 582.6    | 819.1    | 916.9    | 1,016.9                          | 1.92      |
| SEA 48: Birmingham, AL     | 634.1          | 633.0     | 940.9    | 1,359.6  | 1,541.3  | 1,727.2                          | 3.17      |
| SEA 49: Chattanooga, TN    | 376.4          | 311.0     | 435.4    | 438.3    | 698.8    | 782.6                            | 2.07      |
| SEA 49: Nashville, TN      | 1,949.9        | 1,755.8   | 2,220.2  | 3,040.0  | 3,472.8  | 3,836.6                          | 0.59      |
| SEA 50: Fayetteville, TN   | 138.0          | 65.5      | 39.3     | 156.4    | 159.3    | 176.5                            | 1.87      |
| SEA 50: Houston, TX        | 15.4           | 79.8      | 153.4    | 118.7    | 133.4    | 148.6                            | 0.84      |
| SEA 51: Lexington, KY      | 427.4          | 302.4     | 372.2    | 499.3    | 574.4    | 655.7                            | 0.56      |
| SEA 54: Louisville, KY     | 1,173.7        | 1,663.3   | 1,350.8  | 1,731.5  | 2,237.5  | 2,808.4                          | 0.65      |
| SEA 55: Evansville, IN     | 5,594.6        | 2,450.0   | 3,452.1  | 4,673.2  | 6,831.0  | 9,062.0                          | 1.63      |
| SEA 56: Terre Haute, IN    | 499.1          | 331.6     | 407.0    | 643.0    | 878.5    | 1,141.8                          | 0.57      |
| SEA 60: Indianapolis, IN   | 2,998.0        | 3,582.5   | 4,015.8  | 4,612.4  | 5,872.1  | 7,128.9                          | 1.07      |
| SEA 61: Anderson, IN       | 606.7          | 247.9     | 323.4    | 426.9    | 613.4    | 817.3                            | 1.60      |
| SEA 62: Cincinnati, OH     | 2,036.6        | 1,771.5   | 2,200.1  | 2,647.1  | 3,088.6  | 3,537.0                          | 1.41      |
| SEA 63: Dayton, OH         | 2,845.0        | 2,636.3   | 3,280.0  | 4,037.6  | 4,465.3  | 4,897.8                          | 1.20      |
| SEA 64: Columbus, OH       | 2,446.7        | 1,934.0   | 2,479.4  | 2,961.2  | 3,275.6  | 3,589.7                          | 1.47      |
| SEA 66: St. Louis, MO      | 672.1          | 723.1     | 839.1    | 1,165.5  | 1,349.2  | 1,545.8                          | 0.80      |
| SEA 68: Philadelphia, PA   | 1,100.1        | 841.6     | 1,182.3  | 1,750.4  | 2,001.3  | 2,338.3                          | 2.32      |
|                            |                |           |          |          |          |                                  | 1.95      |
|                            |                |           |          |          |          |                                  | 0.73      |

NOTE: Unrounded items may not add to total due to rounding. Data assembled on a county level and aggregated into BEAs.  
Source: BEA, *Regional Accounts*.

Corn is corn for grain. Wheat is all wheat. Soybeans are soy-

the 1990s, the United States has experienced a number of waterborne movements, including the resurgence of waterborne hepatitis, and National Interregional Agricultural Projections (NIAAP) (1999).

AD-A094 363

NATHAN (ROBERT R) ASSOCIATES INC WASHINGTON D C  
PROJECTIONS OF DEMAND FOR WATERBORNE TRANSPORTATION, OHIO RIVER--ETC(U)  
DEC 80

F/G 5/3  
DACW69-78-C-0136  
NL

UNCLASSIFIED

2 of 2  
AD-A  
1045355



|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |

END  
DATE  
FILMED  
2 81  
DTIC

1976 are also those which are expected to experience the greatest decreases in total production in 1980. To some extent, increases in soybean production are expected to offset decreases in corn production.

The 1976-80 production decrease is amplified, to some extent, by the fact that 1976 and earlier years were anomalous in terms of grain production. Because of favorable weather conditions, yields were abnormally high. In addition, relatively high prices induced the planting and harvesting of a disproportionately large number of acres of corn.

Because the 1980 projections were derived by interpolating backwards from 1985 (the first projection year in the USDA NIRAP System), it was felt that caution demanded that these estimates be checked against estimates derived by projecting 1980 state level production from 1976-78 actual production and 1979 intended plantings. This supportive analysis confirmed the accuracy of the initial estimates.

By 1990, the PSAs' production is expected to increase to 25.2 million tons, almost reaching the high level of 1976. By 1990, production in a majority of the PSAs is expected to exceed 1976 production levels (Table 30). Growth in production is expected to be the greatest in the southeastern PSAs.

Between 2000 and 2040, grain production in the PSAs is expected to increase but at a decreasing rate. Total grain production in 2000 is estimated to be 32.5 million tons and increase to 46.7 million tons in 2040, an average annual growth of 0.91 percent. Growth in production is expected to be the greatest in those PSAs which are contained in the States of Alabama, Georgia, and Tennessee. However, production is expected to remain concentrated in those PSAs which encompass areas in the States of Illinois, Indiana, Kentucky, and Ohio.

In the future, grain production in the PSAs will be a decreasing percentage share of projected national grain production. Specifically, corn production in the PSAs in 1990 is expected to represent approximately 7 percent of U.S. production, wheat production will be 2.8 percent, and soybean production will be 11.4 percent. By 2000, total grain production in the PSAs is expected to represent 7.7, 2.8, and 12.5 percent of projected national production of corn, wheat, and soybeans, respectively.

#### IV. TRANSPORTATION CHARACTERISTICS

Two forces work to move grain within the ORS hinterland. These are the ability of the western areas of the hinterland to produce grain surpluses for shipment both within and outside the hinterland and the demand of deficit areas within the hinterland for both PSA and outside production. In 1976, a net total of 3.5 million tons of grain was shipped out of the hinterland. Of this net total, 2.6 million tons were shipped out via water. The gross amount of waterborne grain flows has been and is expected to continue to increase over time. Outbound waterway flows in 1980 are expected to decline from the high levels of 1976 but to recover by 1990. Inbound waterway flows are expected to remain relatively stable between 1976 and 1980 and then to decrease in subsequent years. Local waterway movements, from one point to another within the ORS, will continue to be insignificant in the future (Table 31).

##### A. Existing Modal Split

Because of inadequate data, total shipments and receipts of grain cannot be determined for the PSAs. While both rail and water data are available, there is no source of adequate data to determine inbound and outbound truck movements. The determination of total shipments requires summation of the movements by all modes.

It is not possible to establish the existing modal split of total PSA grain movements. It is possible, however, to develop judgments about the modal split on the basis of available rail and water data, and on the basis of net shipments and receipts implied by the consumption and production estimates made for each PSA. These data provided estimates of net truck movements, and information from shippers and receivers of grain permitted analysis of truck transportation.

Table 31. Ohio River Basin: Production, Consumption and Shipments by Mode of Transportation of Grains, Estimated 1976 and Projected 1980-2040, Selected Years  
(Thousands of tons unless otherwise specified)

|                             | Estimated<br>1976 | Projected |           |           |           | Average annual<br>percentage change |               |
|-----------------------------|-------------------|-----------|-----------|-----------|-----------|-------------------------------------|---------------|
|                             |                   | 1980      | 1990      | 2000      | 2040      | 1976-2000                           | 2000-2040     |
| Production                  | 25,576.9          | 19,859.7  | 25,199.4  | 32,549.6  | 39,361.2  | 46,719.5                            | 1.01 0.91     |
| Consumption                 | 22,081.5          | 22,352.2  | 23,323.4  | 25,139.0  | 26,104.0  | 27,102.8                            | 0.54 0.19     |
| Net shipments (receipts)    | 3,495.4           | (2,492.5) | 1,876.0   | 7,410.6   | 13,257.2  | 19,616.7                            | 3.18 2.46     |
| Net waterborne              | 2,617.0           | 1,119.6   | 2,103.5   | 3,462.9   | 4,839.2   | 6,353.8                             | 1.18 1.53     |
| Net rail                    | 5,048.8           | 2,316.8   | 3,847.2   | 6,562.3   | 9,747.8   | 13,082.4                            | 1.10 1.74     |
| Net truck                   | (4,170.4)         | 5,928.9   | (4,074.7) | (2,616.7) | (1,329.8) | 180.5                               | (1.92) b      |
| Gross waterborne shipments: |                   |           |           |           |           |                                     |               |
| Outbound                    | 4,035.0           | 2,593.5   | 3,492.6   | 4,674.6   | 5,957.5   | 7,372.6                             | 0.62 1.15     |
| Inbound                     | 1,418.0           | 1,473.9   | 1,389.1   | 1,211.7   | 1,118.3   | 1,018.8                             | (0.65) (0.43) |
| Local                       | 129.0             | 86.1      | 114.9     | 156.7     | 199.2     | 246.0                               | 0.76 1.15     |
| Total                       | 5,582.0           | 4,153.5   | 4,996.6   | 6,043.0   | 7,275.0   | 8,637.4                             | 0.33 0.90     |

Note: Projected net shipments (receipts) determined by subtracting projected consumption from projected production. Projected modal split for the PSAs was estimated from projections of modal split for each BEA and BEA segment. For most BEAs, projected modal split remains constant in the future except when data, analyses and conversations with industrial authorities indicated otherwise. Gross waterborne shipments (inbound, outbound, local) were projected by assuming that the relationship between gross and net waterborne shipments in 1976 would remain constant in the future except when data, analyses and conversations with industrial authorities indicated otherwise.

a. Total production of corn, wheat and soybeans only. Corn is corn for grain. Wheat is all wheat. Soybeans are soybeans for beans. Consumption of grains represents the addition of the consumption of corn, wheat and soybeans by livestock, processing and seed.

b. Not defined.

Source: Tables 19, 30 and 35; Waterborne Commerce by Port Equivalents, revised 1976, and ICC Railroad Waybill Sample, 1976, supplied by the U.S. Army Corps of Engineers.

The Ohio River System hinterland has been and is expected to remain (with the exception of 1980) a net exporter of grain. BEAs 55 (Evansville), 60 (Indianapolis), 62 (Cincinnati), 63 (Dayton), and 64 (Columbus) are expected to generate the greatest volume of outbound shipments by both water and rail, with rail continuing to be the most important mode of transport. Historically, most of rail bound movements of grain either originated from BEAs 55, 60, 63, or 64, or were destined for BEAs 44 (Atlanta), 45 (Birmingham), 47 (Huntsville), or 48 (Chattanooga) (Table 32).

Waterborne movements of grain were relatively important in those PSAs where production and/or consumption took place near the waterway. However, the drawing or distribution area of grain movements is more distant from the river than it is for other commodities. For example, aggregates has a 20-mile drawing area, on the average, and grain hauls range from 75 to 100 miles.

The movements of grain by truck in the hinterland were inbound. In general, truck movements were inbound to PSAs that are net consumers of grain. Truck movements predominate in the intra-state movement of grain and in grain movements to contiguous states.

#### B. Intermodal Characteristics

Intermodal transfers of grain commonly have been truck-to-barge-to-truck and truck-to-rail-to-truck movements. They rarely have been barge-rail transfers. When grain is off-loaded to rail or barge, it is generally sent to its final destination (to the processor, to export, to the grain merchandiser). It may, however, also be moved again by truck. Industry authorities and ORS shippers indicated that rail-to-barge or barge-to-rail links are rare and are generally in response to short-term anomalous market situations.

Shippers and receivers along the river were surveyed to ascertain the 1976 percentage distribution of grain shipped which was transshipped from/to landlocked PSAs. Grain traffic flows were determined with identification of the producing BEA as the origin BEA, the point of transfer to water as the shipping BEA, the waterway destination as the receiving BEA, and the ultimate consumption point designated as the destination BEA.

#### C. Factors Affecting Modal Choice

The production, marketing, and utilization of ORS hinterland grain relies on an integrated and complex grain-marketing system.

Table 32. Ohio River Basin: Production, Consumption and Shipments by Mode of Transportation of Grains, <sup>a</sup> by BEAs or BEA Segments, <sup>b</sup> Estimated 1976  
(Thousands of tons)

| BEA and BEA segment        | Production      | Consumption     | Total net      | Shipments (receipts) |                            |                            |                          |  | Net rail       | Net truck        |
|----------------------------|-----------------|-----------------|----------------|----------------------|----------------------------|----------------------------|--------------------------|--|----------------|------------------|
|                            |                 |                 |                | Net                  | Inbound                    | Outbound                   | Local                    |  |                |                  |
| <b>Primary Study Areas</b> | <b>25,576.9</b> | <b>22,081.5</b> | <b>3,495.4</b> | <b>2,617.0</b>       | <b>1,547.0<sup>c</sup></b> | <b>4,164.0<sup>c</sup></b> | <b>129.0<sup>c</sup></b> |  | <b>5,048.8</b> | <b>(4,170.4)</b> |
| BEA 44: Atlanta, GA        | 87.7            | 1,577.8         | (1,490.1)      | (26.3)               | 26.3                       | 0                          | 0                        |  | (726.3)        | (737.5)          |
| BEA 45: Birmingham, AL     | 418.0           | 1,272.9         | (854.9)        | (114.2)              | 114.2                      | 0                          | 0                        |  | (393.8)        | (346.9)          |
| BEA 46: Memphis, TN        | 483.1           | 310.9           | 172.2          | 21.4                 | 0                          | 21.4                       | 0                        |  | 30.1           | 120.7            |
| BEA 47: Huntsville, AL     | 643.1           | 2,059.8         | (1,416.7)      | (420.8)              | 420.8                      | 0                          | 0                        |  | (318.0)        | (677.9)          |
| BEA 48: Chattanooga, TN    | 378.4           | 1,823.0         | (1,444.6)      | (807.9)              | 807.9                      | 0                          | 0                        |  | (493.4)        | (143.3)          |
| BEA 49: Nashville, TN      | 1,949.8         | 2,270.6         | (320.8)        | 269.3                | 0                          | 269.3                      | 0                        |  | 224.2          | (814.3)          |
| BEA 50: Knoxville, TN      | 118.0           | 326.7           | (208.7)        | (11.1)               | 11.1                       | 0                          | 0                        |  | (171.9)        | (25.7)           |
| BEA 52: Huntington, WV     | 105.4           | 256.2           | (150.8)        | 1.1                  | 0                          | 1.1                        | 0                        |  | 10.4           | (162.3)          |
| BEA 53: Lexington, KY      | 427.4           | 1,177.8         | (750.4)        | 34.6                 | 0                          | 34.6                       | 0                        |  | (49.7)         | (735.3)          |
| BEA 54: Louisville, KY     | 1,173.7         | 1,778.6         | (604.9)        | 113.8                | 0                          | 113.8                      | 0                        |  | (22.7)         | (696.0)          |
| BEA 55: Evansville, IN     | 5,594.6         | 2,550.5         | 3,044.1        | 1,744.2              | 163.6                      | 1,907.8                    | 0                        |  | 1,576.5        | (276.6)          |
| BEA 56: Terre Haute, IN    | 498.1           | 83.4            | 414.7          | 76.4                 | 0                          | 76.4                       | 0                        |  | 152.1          | 186.2            |
| BEA 60: Indianapolis, IN   | 3,998.0         | 1,760.8         | 2,237.2        | 243.8                | 0                          | 243.8                      | 0                        |  | 1,721.7        | 271.7            |
| BEA 61: Anderson, IN       | 600.7           | 164.8           | 435.9          | 53.3                 | 0                          | 53.3                       | 0                        |  | 0              | 382.6            |
| BEA 62: Cincinnati, OH     | 2,036.6         | 1,202.3         | 834.3          | 891.0                | 1.1                        | 892.1                      | 0                        |  | 968.0          | (1,024.7)        |
| BEA 63: Dayton, OH         | 2,845.0         | 1,602.7         | 1,242.3        | 183.9                | 0                          | 183.9                      | 0                        |  | 843.3          | 215.1            |
| BEA 64: Columbus, OH       | 2,446.7         | 539.1           | 1,907.6        | 76.9                 | 0                          | 76.9                       | 0                        |  | 1,173.1        | 657.6            |
| BEA 114: St. Louis, MO     | 672.1           | 205.3           | 466.8          | 38.4                 | 0                          | 38.4                       | 0                        |  | 281.5          | 146.9            |
| BEA 115: Paducah, KY       | 1,100.5         | 1,118.3         | (17.8)         | 249.2                | 2.0                        | 251.2                      | 0                        |  | 243.7          | (510.7)          |

Note: Gross and net waterborne rail shipments (receipts) were determined for 1976 from U.S. Army Corps of Engineers waterborne commerce data and Interstate Commerce Commission railroad waybill data. Total net shipments (receipts) were determined by subtracting consumption from production. Net truck shipments (receipts) were determined by subtracting net waterborne and rail shipments (receipts) from total net shipments (receipts).

a. Total production and consumption of corn, wheat and soybeans only. Corn is corn for grain. Wheat is all wheat. Soybeans are soybeans for beans. Consumption of grains represents the addition of the consumption of corn, wheat and soybeans by livestock, processing and seed.

b. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

c. Total Primary Study Area shipments equal inbound, outbound and local shipments for the PSAs as a unit and do equal the sum of shipments reported for each of the BEAs and BEA segments.

Source: Estimated production and consumption from Tables 19 and 30. Water and rail shipments (receipts) from Waterborne Commerce by Port Equivalents, revised 1976, and ICC Railroad Waybill Sample, 1976, supplied by the U.S. Army Corps of Engineers.

The surplus of grain production over grain consumption in any one area indicates the magnitude of grain movements from farm and country elevators to terminal elevators for subsequent shipment to processors, feed manufacturers, and export points.

Grain from farms moves primarily to four types of firms: (1) country elevators; (2) terminal, subterminal, and export elevators; (3) feed mills and manufacturers; and (4) grain processors. By far the largest portion of grain moves to country elevators and terminal elevators and is shipped directly or indirectly to processors, export terminals, and feed and processing firms.

The country elevator operators sell grain through the most profitable channels available. The operators' modal choice to various destinations depends on the demand, the relative cost and availability of transportation facilities, and the distance to be covered.

#### C-1. Transport Costs and Distance

The importance of truck transport is greatest in short hauls within a state and to adjacent states. The market areas served by truck vary during harvest time when shortages of barge and rail facilities combine with storage capacity limitations at terminal facilities to extend market distances.

Water and rail are the modes that have the economic advantage in moving grain to distant points. The elevator operator's marketing and modal choice decision in regard to barge and rail depends upon the price he will receive after subtracting his freight costs to each facility from the bid offered at each of the delivery points. Water and rail compete with and between one another for both grain supplies from inland elevators and for alternative domestic and export markets.

The decision to transport grain by barge is made when the bid at the barge terminal, less transportation costs to that terminal, exceeds the margin available from sales to a local processor, sale to a nearby rail terminal, or direct shipment to a distant export or domestic market. Therefore, the market share of grain moving by barge at any one time is a function not only of relative barge and rail rates to export points (the dominant outlet for barge grain), but also of accessional costs to the river and the relative strength of alternative markets, especially domestic processors and feeders.

---

1. U.S. Department of Transportation, Distribution Systems Analysis, Vol. II of Modal Traffic Impacts of Waterway User Charges (Washington, D.C.: GPO, 1977).



Rail and barge rates to export points, in the absence of institutional factors and anomalous explanatory variables, define a hinterland along the waterway from which barge terminals have an economic advantage in attracting grain. Consider an example in which the bid for export corn at the Gulf is \$3.60 per bushel, the barge rate from an upriver barge terminal is 17 cents per bushel (plus transfer costs of 3 cents per bushel at the terminal including handling and shrinkage), and the rail rate to the Gulf from inland terminals is 34 cents per bushel. An inland elevator operator's modal choice will be for barge only if the cost of transporting grain to the river terminal is less than 14 cents. Since 14 cents is sufficient to truck a bushel of grain about 90 to 100 (highway) miles, the export grain would, hypothetically, move by barge only from elevators within this distance of the river. The extent to which this differential widens or narrows determines, to some extent, the area from which the barge terminal operator can compete in drawing grain for the market.<sup>1</sup>

Over the course of the year, barge rates will fluctuate in response to the demand for transportation. Barge rates are highest during harvest time, when the demand for transportation is the highest. Barge rate fluctuations are reflected in the differential between the bid at the river elevator and the bid for export at the Gulf. From season to season, the competitive areas for rail and barge shipments for export will vary. This is a function of the ability of barge rates to respond to demands in the short run and the inability of rail rates to respond because of Interstate Commerce Commission (ICC) regulations. As barge rates increase, the distances from the river that barge terminal operators can competitively draw grain decreases. On the other hand, the drawing area of a river terminal is extended an additional 20 or 30 miles from the river during the slack season when barge rates are depressed.

#### C-2. Other Modal Choice Factors

Among these are physical restrictions, institutional limitations, the inability to alter transportation supply in the short run, the location and facilities of consumers and suppliers, and the requirement for timely shipments.

---

1. The above discussion is meant to be purely illustrative of how different modal rate structures affect modal choice, at any one point of time, and to the exclusion of other factors. Of course, other variables discussed in this section (e.g., time and institutional relationships such as those between a grain merchandising operation and its subsidiary processing facility) interplay with rates to affect modal choice.

a. Physical Restrictions

Physical restrictions result from natural limitations such as topography and climatic patterns. Restrictions that affect the economic flow of grain from surplus areas to deficit and export markets are the directional flow of rivers, the location of mountain ranges, and weather. The strength of various markets and modal choices during the year vary as a function of the weather. During the winter months, the use of the northern seaway may be restricted, and under severe weather conditions more southern river routes may be blocked. When rivers are used to transport grain from surplus to deficit areas, the production origin and consumption destination must be on or near the river.

Such physical restrictions as mountain ranges, which are obstructions to the free movement of grain, create additional marketing costs. The effect of physical restrictions often have a more dynamic influence on market structure than transportation, as minimizing model solutions indicate.

b. Institutional Limitations

Institutional limitations established by governmental policies and industry practices may restrict the flow of grain, but also may be subject to rapid change. Such limitations include railroad rate zones and territories, changes in rail and other modal rates, and contractual arrangements of shippers.

Each rail rate territory operates independently in the development of rail rates. This factor creates difficulty in the negotiation of joint, proportional, or combinations of rates among rate territories. The problem associated with the routing and exchange of rail cars among railroad companies from different territories, and even among railroads in the same territory, can sometimes substantially restrict a free flow of grain.

Rail rates are controlled by the ICC, and the action of this agency can significantly affect the grain marketing structure and the modal choice of both the shippers and receivers. Railroads can, within their limited rate flexibility, affect the demand for

---

1. B.F. Jones, J.W. Sharp, and E. Dean Baldwin, Structure of the Grain Market in Surplus Feed Grain Areas, Southern Cooperative Series No. 207, Research Bulletin No. 927 (West Lafayette, IN: Purdue University, 1975).

rail transport in regard to both volume and seasonality. Through the provision of special rate or mileage allowances for grain moving in shipper-owned/leased cars, the railroads hope to affect modal choice. Some railroads publish tariffs under which the rate per ton varies in accordance with the volume of traffic shipped in some interval (nine months or one year). This rate structure encourages continuous rail shipment throughout the year because a shipment each week is required to meet the volume minimum. Once the requirement is met, the rate is extremely attractive, even when barge rates are at or below annual contract rates.

Various rail rate categories are available in areas of the ORS hinterland, but are not uniformly available to all firms due to firm size or location, or because of particular tariff regulations. It has been found that access to most rate categories tends to increase with the size of the firm, although the pattern is not uniform. Firms with the largest grain storage capacities, and with the equipment and facilities to load a train within a designated time period before demurrage charges are incurred, are able to use almost every rail rate available. Such large-scale elevators often can utilize unit trains that provide faster turnaround time, higher car-utilization rates, and greater efficiency in grain movement. The ability of any firm to use unit trains is a function of rates, the existence of compatible origins and destinations, and the ability of the elevator to loadout grain at an adequate per hour rate (10,000 bushels an hour). The access and use by smaller firms of multiple car rates is limited by their grain storage capacity and loadout rates, i.e., by the volume of grain they have available and are able to move at any one time.

Contractual arrangements for transportation exist in the grain marketing system. A significant fraction of barge grain is shipped under annual contract that guarantees a certain number of barges per month to a shipper at a fixed cost. Although the barge rate does not fluctuate for this portion of barge shipments, the price paid for the grain at the barge terminal is the same as for grain loaded on barges purchased at the spot rate. Also, since the

---

1. As of 1978, there were at least 18 unit train facility sites in the Ohio River System hinterland: two in BEA 54 (Louisville), three in BEA 60 (Indianapolis), three in BEA 62 (Cincinnati), four in BEA 63 (Dayton), and six in BEA 64 (Columbus). Ohio Agricultural Research and Development Center, Grain Facilities in the U.S. Specializing in Originating Grain for Export and Soybean Processing Plants, Research Circular 241, by John Sharp (Wooster, OH: OARDC, 1978).

shipper has the option of selling his barge contracts, the opportunity cost of the transportation is equal to the spot rate.<sup>1</sup>

c. Transportation Supply

In the short run, the supply of transportation available to move grain from surplus to deficit areas is relatively fixed. However, in the long run, changes and developments in the total transportation network are possible. Changes such as the construction of a riverside terminal facility, the abandonment of rail trackage, and changes in transportation technology (hopper cars, containerized shipments, etc.) can have a profound effect on the grain marketing system.

The flow of grain at harvest time is restricted by the economic and technical inability of the various modes to substantially increase their transportation facilities in the short run, or to substantially reduce the delay in car and barge turnaround times. However, the fixed capital investment of any shipper in any one mode is made on the basis of the length of the peak harvest period relative to the slack period, when capital will remain idle.

d. Consumer and Supplier Location  
Facilities and Access

The choice of mode for the transportation of grain is influenced by transportation rates and time implicit in the location of consumption and production areas. Consumption areas can change over time, while production areas remain relatively fixed. In the grain marketing structure, the free flow of grain is possible when origin and destination pairs are established. As the volume of grain moved on such links stabilizes and increases, modal rates may alter.

The movement of grain requires certain minimum loading and unloading facilities, storage capacity, and grain elevators. A riverside grain loading facility requires an appropriate site and some means of conveying grain from the elevator to the barge. Rail spurs must exist for an elevator to move grain by rail. The ability of an elevator to move grain in volume (and to take advantage of certain rate structures) is limited by storage capacity and loadout time.

---

1. U.S. Department of Transportation, Distribution System Analysis, Vol. II of Modal Traffic Impacts of Waterway Users Charges (Washington, D.C.: GPO, 1977).

Not all elevators have equal access to all transportation modes, and modal choice can be limited. The largest grain exporters are committed to a multi-mode transport strategy. They own trucks, barges, rail cars, rail and barge terminals in the producing areas, and port facilities which are constructed to throughput both barge and rail grain. This allows the multi-mode owner flexibility in responding to various markets, rate structures, and market time constraints.

e. Time

Time is an important factor in modal choice by itself and as it is embodied in the seasonality of grain movements.<sup>1</sup> The ability of various modes to move grain a certain distance and within a certain time is variable. Time becomes a decision factor in modal choice in situations where the even flow of grain is necessary to operate a processing facility economically, or to allow an export bound vessel to sail with a full load. The pressure of such time frames will result in modal choices that are atypical of the general flow between any one origin or destination.

D. Forecasting Procedures and Assumptions

Generally, the projections of ORS grain movements assume that future origin and destination links and future modal split will conform to the links and modal split in 1976. The general assumption underlying this procedure was that 1976 flows were representative of future flows to a certain degree. This assumption was modified in certain cases when, as a result of discussions with industry sources, specific future changes in links and modal split could be identified. For both water and rail movements, the relationship between inbound, outbound, and net shipments was held constant. Deviations from the 1976 pattern were projected only when specific changes were anticipated. Based on the assumption that there is no change in relative prices of transport modes, and

---

1. In 1970, for example, February, March, October, and November were the peak months of outbound grain flows from Illinois, Indiana, and Ohio. Fluctuations during February and March were caused by significant increases in corn and soybean outflows, probably to processing or export. The fluctuations in October and November resulted from increased out-of-state shipments as a result of grain (corn and soybean) harvest. James L. Stallings, et al., Grain Movements Between Southern and Corn Belt States. Southern Cooperative Series, Bulletin No. 209 (Auburn, AL: Alabama Agricultural Experiment Station, 1976).

based on the assumption that relative transport time will not change significantly, it is expected that the future modal split will not vary significantly from the 1976 split.

D-1. Forecasting Procedures for  
BEA Waterway Flows, 1980-2040

The calculation of waterway flows for each PSA in the ORS hinterland was completed in a two-step process. Gross inbound waterborne receipts for each PSA were estimated as both a proportion of consumption and as a proportion of total net shipments. Gross outbound waterborne shipments for each PSA were estimated as both a proportion of production and as a proportion of total net shipments. In most cases, the relationship of net shipments to gross inbound and outbound waterborne movements was chosen. However, the relationship between gross inbound receipts and consumption was chosen when a PSA was a net producer but had waterborne receipts. The gross outbound shipment relationship to production was chosen when the PSA was a net consumer but had waterborne shipments. The choice of this alternative relationship was made in the specific cases of BEAs 55 (Evansville) and 62 (Cincinnati), where it was felt that the relationship of gross inbound and outbound waterborne movement to net shipments underestimated the volume of waterborne movements in these BEAs, which historically have been responsible for the generation of the greatest proportion of ORS hinterland waterborne grain movements.

The choice of relating either net shipments or production or consumption to gross outbound or gross inbound waterborne movements, respectively, remained consistent across all projection years.

Net waterborne movements for each PSA for each projection year were defined as gross outbound minus gross inbound.

D-2. Forecasting Procedures for  
Rail Movements, 1980-2040

The calculation of net rail movements for each PSA in the hinterland was obtained by the same process outlined above. Gross inbound rail receipts were estimated as a proportion of consumption and of net shipments; and, gross outbound rail shipments were estimated as a proportion of production and of net shipments. The choice of the production and consumption relationship was made in the case of BEAs 55 (Evansville) and 62 (Cincinnati), where the net shipment relationship was believed to underestimate expected rail

movements. This alternative relationship was also chosen where a PSA was a net receiver but had outbound rail shipments or was a net producer and had inbound rail receipts. The choice remains consistent across all projection years and the same as that made in regards to waterway movements.

Net rail movements for each PSA for each projection year were defined as gross outbound minus gross inbound.

D-3. Forecasting Procedures for  
Estimating Truck Movements  
and PSAs Receipts and  
Shipments of Waterborne  
Movements for BEAs Exterior  
to the ORB

Truck movements were projected by assuming that net truck was equal to total net shipments less net water and net rail shipments.

Waterway flows from BEAs exterior to the ORS to PSAs were related to the future consumption of each PSA within the hinterland. Flows to BEAs exterior to the ORS from PSAs were related to the future production of each PSA. These relationships were based on historical relationships. Through this procedure, the change in waterborne movements for the hinterland as a whole is captured by the different growth rates of production and consumption of each PSA in the hinterland.

E. Probable Future Modal Split

The probable future modal split of grain shipments within the PSAs is presented in Tables 33 and 34 for 1980 and 1990, respectively. A summary of the modal split of hinterland grain movements for all projection years and for the 1976 base year was presented in Table 31.

The modal split of each PSA is not expected to shift dramatically. In general, those PSAs that have historically been either large outbound or inbound waterway shippers or receivers are expected to remain large shippers. The same is true of rail shippers and/or receivers. The proportional relationship of net rail to net water shipments is expected to remain relatively stable, with net rail shipments being about twice the volume of net water shipments.

Table 33. Ohio River Basin: Production, Consumption and Shipments by Mode of Transportation of Grains,<sup>a</sup> by BEAs or BEA Segments, Projected 1980  
(Thousands of tons)

| BEA and BEA segment      | Production | Consumption | Total net | Shipments (receipts) |                      |                      |                   |          |           |  |
|--------------------------|------------|-------------|-----------|----------------------|----------------------|----------------------|-------------------|----------|-----------|--|
|                          |            |             |           | Net                  | Water                |                      |                   | Net rail | Net truck |  |
|                          |            |             |           |                      | Inbound              | Outbound             | Local             |          |           |  |
| Primary Study Areas      | 19,859.7   | 22,352.2    | (2,492.5) | 1,119.6              | 1,560.0 <sup>c</sup> | 2,679.6 <sup>c</sup> | 86.1 <sup>c</sup> | 2,316.8  | (5,928.9) |  |
| BEA 44: Atlanta, GA      | 113.3      | 1,558.6     | (1,445.3) | (25.4)               | 25.4                 | --                   | --                | (704.4)  | (715.5)   |  |
| BEA 45: Birmingham, AL   | 439.4      | 1,234.0     | (794.6)   | (106.2)              | 106.2                | --                   | --                | (366.0)  | (322.4)   |  |
| BEA 46: Memphis, TN      | 477.8      | 353.1       | 124.7     | 15.5                 | --                   | 15.5                 | --                | 21.8     | 87.4      |  |
| BEA 47: Huntsville, AL   | 663.0      | 2,062.9     | (1,399.9) | (415.8)              | 415.8                | --                   | --                | (310.6)  | (673.5)   |  |
| BEA 48: Chattanooga, TN  | 311.9      | 1,812.4     | (1,500.5) | (839.3)              | 839.3                | --                   | --                | (614.2)  | (47.0)    |  |
| BEA 49: Nashville, TN    | 1,765.8    | 2,453.3     | (687.5)   | 244.0                | --                   | 244.0                | --                | 128.6    | (1,060.1) |  |
| BEA 50: Knoxville, TN    | 65.5       | 339.5       | (274.0)   | (14.6)               | 14.6                 | --                   | --                | (238.8)  | (20.6)    |  |
| BEA 52: Huntington, WV   | 79.8       | 276.7       | (196.9)   | 0.8                  | --                   | 0.8                  | --                | 7.9      | (205.6)   |  |
| BEA 53: Lexington, KY    | 302.4      | 1,233.0     | (930.6)   | 24.5                 | --                   | 24.5                 | --                | (61.6)   | (893.5)   |  |
| BEA 54: Louisville, KY   | 1,060.3    | 1,747.3     | (687.0)   | 102.8                | --                   | 102.8                | --                | (65.3)   | (724.5)   |  |
| BEA 55: Evansville, IN   | 2,450.0    | 2,428.6     | 21.4      | 680.5                | 155.7                | 836.2                | --                | 583.2    | (1,242.3) |  |
| BEA 56: Terre Haute, IN  | 393.6      | 144.5       | 249.1     | 45.9                 | --                   | 45.9                 | --                | 91.4     | 111.8     |  |
| BEA 60: Indianapolis, IN | 3,582.5    | 1,776.9     | 1,805.6   | 196.8                | --                   | 196.8                | --                | 1,365.3  | 243.5     |  |
| BEA 61: Anderson, IN     | 247.9      | 156.3       | 91.6      | 11.2                 | --                   | 11.2                 | --                | (14.8)   | 95.2      |  |
| BEA 62: Cincinnati, OH   | 1,771.5    | 1,234.4     | 537.1     | 774.5                | 1.1                  | 775.6                | --                | 588.3    | (825.7)   |  |
| BEA 63: Dayton, OH       | 2,636.3    | 1,719.6     | 916.7     | 135.7                | --                   | 135.7                | --                | 622.3    | 158.7     |  |
| BEA 64: Columbus, OH     | 1,934.0    | 595.7       | 1,338.3   | 53.8                 | --                   | 53.8                 | --                | 778.6    | 505.9     |  |
| BEA 114: St. Louis, MO   | 723.1      | 194.4       | 528.7     | 44.7                 | --                   | 44.7                 | --                | 318.8    | 165.2     |  |
| BEA 115: Paducah, KY     | 841.6      | 1,031.0     | (189.4)   | 190.2                | 1.9                  | 192.1                | --                | 186.3    | (565.9)   |  |

Note: Projected net shipments (receipts) determined by subtracting projected consumption from projected production. Projected modal split for the PSAs was estimated from projections of modal split for each BEA and BEA segment. For most BEAs, projected modal split remains constant in the future except when data, analyses and conversations with industrial authorities indicated otherwise. Gross waterborne shipments (inbound, outbound, local) were projected by assuming that the relationship between gross and net waterborne shipments in 1976 would remain constant in the future except when data, analyses and conversations with industrial authorities indicated otherwise.

a. Total production and consumption of corn, wheat and soybeans only. Corn is corn for grain. Wheat is all wheat. Soybeans are soybeans for beans. Consumption of grains represents the addition of the consumption of corn, wheat, and soybeans by livestock, processing and seed.

b. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

c. Total Primary Study Area shipments equal inbound, outbound and local shipments for the PSAs as a unit and do not equal the sum of shipments reported for each of the BEAs and BEA segments.

Source: Tables 19, 30 and 32; Waterborne Commerce by Port Equivalents, revised 1976, and ICC Railroad Waybill Sample, 1976, supplied by the U.S. Army Corps of Engineers.



Table 34. Ohio River Basin: Production, Consumption and Shipments by Mode of Transportation of Grains, by BEAs or BEA Segments, a Projected 1990  
(Thousands of tons)

| BEA and BEA segment      | Production | Consumption | Total net | Shipments (receipts) |                      |                      |                    |         | Net rail | Net truck |
|--------------------------|------------|-------------|-----------|----------------------|----------------------|----------------------|--------------------|---------|----------|-----------|
|                          |            |             |           | Net                  | Water                |                      |                    | Local   |          |           |
|                          |            |             |           |                      | Inbound              | Outbound             |                    |         |          |           |
| Primary Study Areas      | 25,199.4   | 23,323.4    | 1,876.0   | 2,103.5              | 1,504.0 <sup>C</sup> | 3,607.5 <sup>C</sup> | 114.9 <sup>C</sup> | 3,847.2 |          | (4,074.7) |
| BEA 44: Atlanta, GA      | 154.5      | 1,666.5     | (1,512.0) | (26.6)               | 26.6                 | --                   | --                 | (737.0) |          | (748.4)   |
| BEA 45: Birmingham, AL   | 637.0      | 1,305.0     | (668.0)   | (89.2)               | 89.2                 | --                   | --                 | (307.7) |          | (271.1)   |
| BEA 46: Memphis, TN      | 582.6      | 389.0       | 193.6     | 24.1                 | --                   | 24.1                 | --                 | 33.8    |          | 135.7     |
| BEA 47: Huntsville, AL   | 930.9      | 2,201.7     | (1,270.8) | (377.4)              | 377.4                | --                   | --                 | (238.9) |          | (654.5)   |
| BEA 48: Chattanooga, TN  | 436.3      | 1,917.2     | (1,480.9) | (828.5)              | 828.5                | --                   | --                 | (445.1) |          | (207.3)   |
| BEA 49: Nashville, TN    | 2,210.2    | 2,623.3     | (413.1)   | 305.1                | --                   | 305.1                | --                 | 245.0   |          | (963.2)   |
| BEA 50: Knoxville, TN    | 89.3       | 354.7       | (265.4)   | (14.1)               | 14.1                 | --                   | --                 | (227.5) |          | (23.8)    |
| BEA 52: Huntington, WV   | 100.4      | 268.7       | (168.3)   | 1.0                  | --                   | 1.0                  | --                 | 9.9     |          | (179.2)   |
| BEA 53: Lexington, KY    | 377.2      | 1,291.6     | (914.4)   | 30.6                 | --                   | 30.6                 | --                 | (60.5)  |          | (884.5)   |
| BEA 54: Louisville, KY   | 1,300.8    | 1,818.1     | (517.3)   | 126.3                | --                   | 126.3                | --                 | 24.2    |          | (667.8)   |
| BEA 55: Evansville, IN   | 3,453.1    | 2,576.3     | 876.8     | 1,013.2              | 165.1                | 1,178.3              | --                 | 891.0   |          | (1,027.4) |
| BEA 56: Terre Haute, IN  | 497.0      | 148.7       | 348.3     | 64.2                 | --                   | 64.2                 | --                 | 127.8   |          | 156.3     |
| BEA 60: Indianapolis, IN | 4,015.8    | 1,829.1     | 2,186.7   | 238.4                | --                   | 238.4                | --                 | 1,655.5 |          | 292.8     |
| BEA 61: Anderson, IN     | 323.4      | 153.5       | 169.9     | 20.8                 | --                   | 20.8                 | --                 | (10.8)  |          | 159.9     |
| BEA 62: Cincinnati, OH   | 2,200.1    | 1,239.7     | 960.4     | 962.3                | 1.1                  | 963.4                | --                 | (85.2)  |          | 83.3      |
| BEA 63: Dayton, OH       | 3,380.0    | 1,674.5     | 1,705.5   | 252.4                | --                   | 252.4                | --                 | 1,157.7 |          | 295.4     |
| BEA 64: Columbus, OH     | 2,479.4    | 569.6       | 1,909.8   | 77.0                 | --                   | 77.0                 | --                 | 1,169.3 |          | 663.5     |
| BEA 114: St. Louis, MO   | 839.1      | 206.1       | 633.0     | 53.6                 | --                   | 53.6                 | --                 | 381.7   |          | 197.7     |
| BEA 115: Paducah, KY     | 1,192.3    | 1,090.1     | 102.2     | 270.3                | 2.0                  | 272.3                | --                 | 264.0   |          | (432.1)   |

Note: Projected net shipments (receipts) determined by subtracting projected consumption from projected production. Projected modal split for the PSAs was estimated from projections of modal split for each BEA and BEA segment. For most BEAs, projected modal split remains constant in the future except when data, analyses and conversations with industrial authorities indicated otherwise. Gross waterborne shipments (inbound, outbound, local) were projected by assuming that the relationship between gross and net waterborne shipments in 1976 would remain constant in the future except when data, analyses and conversations with industrial authorities indicated otherwise.

- Total production and consumption of corn, wheat and soybeans only. Corn is corn for grain. Wheat is all wheat. Soybeans are soybeans for beans. Consumption of grains represents the addition of the consumption of corn, wheat and soybeans by livestock, processing and seed.
- BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.
- Total Primary Study Area shipments equal inbound, outbound and local shipments for the PSAs as a unit and do not equal the sum of shipments reported for each of the BEAs and BEA segments.

Source: Tables 19, 30 and 32; Waterborne Commerce by Port Equivalents, revised 1976, and ICC Railroad Waybill Sample, 1976, supplied by the U.S. Army Corps of Engineers.

The substantial decreases in production of corn in the hinterland in 1980, and the related decrease in the volume of grain available for shipment from the PSAs as a whole, are expected to impact both rail and water shipments almost equally. Net rail and net water shipments are expected to decrease over 50 percent in 1980 from the 1976 high. The most dramatic decreases in both net rail and net water shipments are expected to occur in BEA 55 (Evansville), which historically has been the hinterland's predominant rail and water shipper.

#### F. Probable Future Waterway Flows

Projected BEA-to-BEA waterway flows for the years 1980, 1990, 2000, 2020, and 2040 are presented in Table 35. Growth indices derived from the traffic projections are presented in Table 36. Projected waterborne grain flows for each projection year are based on the previous projection year's flows, adjusted to reflect expected changes.

Gross waterborne grain movements, as projected, are expected to increase at an annual rate of 0.33 percent between 1976 and 2000, and to exceed the 1976 level of 5.6 million tons. Between 2000, and 2040, gross waterborne grain movements are expected to increase at an average annual rate of 0.90 percent (Table 31).

Between 1976 and 2040, outbound shipments are expected to increase following an initial decline in 1980 due to decreased area production, specifically in PSAs with high surplus production and high outbound waterborne movements. Inbound waterborne grain movements are expected to decrease gradually in the long run; this has been the historical trend. Between 1976 and 2000, inbound flows are expected to decrease at an annual rate of 0.65 percent. Local waterborne grain movements in the ORS are expected to increase steadily between 1990 and 2040, following initial decreases from the 1976 level in 1980 and 1990. However, local movements are expected to remain proportionally small relative to gross ORS waterborne grain movements.

Table 35. Ohio River System: Waterborne Traffic of Grains, by Origin BEA, Shipping BEA, Receiving BEA and Destination BEA, Estimated 1976 and Projected 1980-2040, Selected Years

|               |                 |                  |                    | FOR COMMODITY GROUP 05 IN HUNDREDS OF TONS |      |       |       |       |       |
|---------------|-----------------|------------------|--------------------|--|------|-------|-------|-------|-------|
| ORIGIN<br>BEA | SHIPPING<br>BEA | RECEIVING<br>BEA | DESTINATION<br>BEA | 1976                                       | 1980 | 1990  | 2000  | 2020  | 2040  |
| 046           | 047             | 047              | 045                | 10   | 7    | 9     | 16    | 17    | 21    |
| 046           | 047             | 047              | 047                | 19   | 14   | 6     | 10    | 13    | 14    |
| 046           | 047             | 047              | 048                | 19   | 14   | 22    | 38    | 41    | 47    |
| 046           | 047             | 111              | 111                | 10   | 7    | 11    | 19    | 21    | 24    |
| 046           | 047             | 137              | 137                | 29   | 21   | 33    | 56    | 66    | 76    |
| 046           | 047             | 138              | 138                | 127  | 92   | 160   | 277   | 331   | 381   |
| 049           | 115             | 038              | 038                | 11   | 12   | 13    | 17    | 22    | 28    |
| 049           | 047             | 047              | 045                | 11   | 9    | 11    | 16    | 17    | 21    |
| 049           | 47              | 047              | 047                | 23   | 20   | 8     | 10    | 13    | 15    |
| 049           | 047             | 047              | 048                | 26   | 24   | 29    | 41    | 43    | 49    |
| 049           | 047             | 048              | 048                | 22   | 21   | 25    | 34    | 37    | 41    |
| 049           | 048             | 050              | 050                | 20   | 22   | 26    | 30    | 33    | 37    |
| 049           | 055             | 055              | 055                | 50   | 41   | 56    | 79    | 118   | 145   |
| 049           | 047             | 111              | 111                | 12   | 11   | 14    | 19    | 23    | 26    |
| 049           | 047             | 137              | 137                | 37   | 32   | 41    | 57    | 64    | 71    |
| 049           | 055             | 137              | 137                | 10   | 9    | 11    | 16    | 17    | 19    |
| 049           | 047             | 138              | 138                | 350  | 317  | 399   | 550   | 617   | 686   |
| 049           | 048             | 138              | 138                | 62   | 56   | 71    | 97    | 109   | 122   |
| 049           | 049             | 138              | 138                | 64   | 58   | 73    | 100   | 113   | 126   |
| 049           | 055             | 138              | 138                | 1645                                       | 1536 | 1932  | 2661  | 2947  | 3324  |
| 049           | 115             | 138              | 138                | 300  | 272  | 342   | 471   | 529   | 588   |
| 052           | 052             | 141              | 141                | 11   | 8    | 10    | 12    | 14    | 15    |
| 053           | 042             | 137              | 137                | 11   | 8    | 10    | 13    | 15    | 17    |
| 053           | 042             | 138              | 138                | 325  | 230  | 287   | 379   | 436   | 498   |
| 053           | 042             | 946              | 946                | 10   | 7    | 9     | 12    | 14    | 16    |
| 054           | 054             | 047              | 045                | 24   | 20   | 21    | 30    | 36    | 38    |
| 054           | 054             | 047              | 047                | 35   | 31   | 11    | 11    | 13    | 16    |
| 054           | 054             | 047              | 048                | 28   | 28   | 34    | 44    | 53    | 65    |
| 054           | 054             | 055              | 055                | 13   | 10   | 14    | 22    | 43    | 82    |
| 054           | 054             | 138              | 138                | 11   | 10   | 13    | 17    | 21    | 27    |
| 054           | 042             | 138              | 138                | 1027                                       | 929  | 1170  | 1556  | 2004  | 2497  |
| 055           | 055             | 038              | 038                | 20   | 9    | 12    | 17    | 23    | 32    |
| 055           | 055             | 047              | 044                | 11   | 8    | 13    | 19    | 36    | 62    |
| 055           | 055             | 047              | 045                | 89   | 39   | 52    | 66    | 92    | 124   |
| 055           | 055             | 047              | 047                | 112  | 47   | 23    | 32    | 53    | 59    |
| 055           | 055             | 047              | 048                | 199  | 46   | 78    | 109   | 145   | 183   |
| 055           | 055             | 048              | 048                | 200  | 85   | 142   | 200   | 247   | 336   |
| 055           | 055             | 115              | 115                | 20   | 19   | 20    | 21    | 21    | 22    |
| 055           | 055             | 137              | 137                | 416  | 184  | 269   | 364   | 514   | 683   |
| 055           | 055             | 138              | 138                | 17651                                      | 1731 | 10908 | 15392 | 21605 | 28753 |
| 055           | 042             | 138              | 138                | 109  | 44   | 62    | 87    | 122   | 163   |
| 055           | 115             | 138              | 138                | 75   | 33   | 46    | 65    | 92    | 122   |
| 055           | 055             | 140              | 140                | 31   | 13   | 19    | 27    | 38    | 50    |
| 055           | 055             | 141              | 141                | 63   | 26   | 37    | 55    | 75    | 98    |
| 055           | 055             | 143              | 143                | 30   | 13   | 19    | 26    | 37    | 49    |
| 055           | 055             | 914              | 914                | 92   | 41   | 57    | 80    | 113   | 151   |
| 055           | 055             | 946              | 946                | 59   | 24   | 34    | 49    | 69    | 91    |
| 056           | 055             | 047              | 047                | 12   | 8    | 7     | 5     | 8     | 10    |
| 056           | 055             | 048              | 048                | 12   | 7    | 10    | 14    | 21    | 29    |
| 056           | 055             | 137              | 137                | 20   | 12   | 17    | 23    | 34    | 47    |
| 056           | 055             | 138              | 138                | 720  | 632  | 612   | 849   | 1252  | 1704  |
| 057           | 057             | 047              | 045                | 14   | 13   | 11    | 10    | 8     | 8     |

(Continued)

Table 35. (Continued)

| ORIGIN<br>REA | SHIPPING<br>BEA | RECEIVING<br>REA | DESTINATION<br>HEA | FOR COMMODITY GROUP 05 IN HUNDREDS OF TONS |      |      |       |       |       |
|---------------|-----------------|------------------|--------------------|--|------|------|-------|-------|-------|
|               |                 |                  |                    | 1976                                       | 1980 | 1990 | 2000  | 2020  | 2040  |
| 057           | 057             | 047              | 047                | 55   | 56   | 51   | 37    | 32    | 27    |
| 057           | 057             | 047              | 048                | 19   | 21   | 19   | 17    | 16    | 14    |
| 057           | 057             | 048              | 048                | 30   | 32   | 30   | 28    | 26    | 23    |
| 060           | 054             | 047              | 045                | 11   | 8    | 9    | 11    | 15    | 16    |
| 060           | 054             | 047              | 047                | 16   | 13   | 5    | 5     | 6     | 8     |
| 060           | 062             | 047              | 047                | 15   | 12   | 4    | 4     | 5     | 8     |
| 060           | 054             | 047              | 048                | 15   | 12   | 15   | 18    | 26    | 33    |
| 060           | 062             | 048              | 048                | 20   | 17   | 21   | 25    | 34    | 45    |
| 060           | 062             | 055              | 055                | 14   | 11   | 15   | 21    | 43    | 64    |
| 060           | 062             | 137              | 137                | 31   | 26   | 31   | 37    | 55    | 72    |
| 060           | 054             | 138              | 138                | 506  | 408  | 499  | 613   | 887   | 1158  |
| 060           | 062             | 138              | 138                | 1785                                       | 1440 | 1760 | 2162  | 3129  | 4086  |
| 060           | 062             | 914              | 914                | 11   | 9    | 11   | 14    | 21    | 27    |
| 060           | 062             | 946              | 946                | 14   | 12   | 14   | 18    | 25    | 32    |
| 061           | 062             | 048              | 048                | 14   | 3    | 5    | 8     | 14    | 20    |
| 061           | 062             | 137              | 137                | 10   | 2    | 4    | 6     | 10    | 15    |
| 061           | 062             | 138              | 138                | 509  | 107  | 199  | 317   | 538   | 781   |
| 062           | 062             | 038              | 038                | 13   | 9    | 14   | 17    | 19    | 17    |
| 062           | 062             | 047              | 045                | 27   | 21   | 26   | 35    | 37    | 34    |
| 062           | 062             | 047              | 047                | 42   | 37   | 15   | 17    | 18    | 19    |
| 062           | 062             | 047              | 048                | 35   | 32   | 44   | 52    | 58    | 64    |
| 062           | 062             | 048              | 048                | 41   | 38   | 52   | 61    | 68    | 75    |
| 062           | 062             | 055              | 055                | 35   | 28   | 42   | 51    | 76    | 120   |
| 062           | 062             | 133              | 133                | 12   | 9    | 13   | 16    | 19    | 21    |
| 062           | 062             | 137              | 137                | 145  | 124  | 154  | 188   | 217   | 248   |
| 062           | 062             | 138              | 138                | 8460                                       | 7360 | 9154 | 11006 | 12842 | 14695 |
| 062           | 062             | 914              | 914                | 42   | 38   | 45   | 56    | 66    | 75    |
| 062           | 062             | 946              | 946                | 69   | 60   | 75   | 91    | 106   | 123   |
| 063           | 062             | 047              | 047                | 13   | 8    | 4    | 5     | 0     | 0     |
| 063           | 062             | 048              | 048                | 17   | 13   | 25   | 34    | 41    | 48    |
| 063           | 062             | 055              | 055                | 10   | 6    | 11   | 16    | 28    | 32    |
| 063           | 062             | 137              | 137                | 30   | 22   | 40   | 57    | 66    | 76    |
| 063           | 062             | 138              | 138                | 1744                                       | 1289 | 2410 | 3342  | 3943  | 4547  |
| 063           | 062             | 914              | 914                | 11   | 8    | 15   | 21    | 25    | 28    |
| 063           | 062             | 946              | 946                | 14   | 11   | 19   | 27    | 32    | 37    |
| 064           | 062             | 048              | 048                | 15   | 10   | 14   | 18    | 21    | 24    |
| 064           | 062             | 055              | 055                | 12   | 8    | 13   | 16    | 26    | 29    |
| 064           | 062             | 137              | 137                | 12   | 4    | 13   | 15    | 17    | 14    |
| 064           | 062             | 138              | 138                | 708  | 494  | 708  | 847   | 995   | 1104  |
| 064           | 064             | 138              | 138                | 22   | 15   | 22   | 28    | 31    | 34    |
| 077           | 077             | 047              | 044                | 26   | 26   | 26   | 25    | 23    | 20    |
| 077           | 077             | 047              | 045                | 332  | 325  | 261  | 229   | 182   | 145   |
| 077           | 077             | 047              | 047                | 603  | 611  | 551  | 430   | 403   | 325   |
| 077           | 077             | 047              | 048                | 381  | 405  | 389  | 333   | 296   | 240   |
| 077           | 077             | 048              | 048                | 133  | 141  | 136  | 116   | 103   | 101   |
| 078           | 078             | 047              | 044                | 16   | 15   | 16   | 15    | 14    | 12    |
| 078           | 078             | 047              | 045                | 232  | 228  | 182  | 154   | 122   | 96    |
| 078           | 078             | 047              | 047                | 601  | 607  | 549  | 428   | 392   | 313   |
| 078           | 078             | 047              | 048                | 263  | 282  | 267  | 230   | 204   | 203   |
| 078           | 078             | 048              | 048                | 100  | 107  | 102  | 87    | 77    | 77    |
| 078           | 078             | 062              | 062                | 11   | 11   | 11   | 12    | 13    | 13    |
| 079           | 079             | 047              | 045                | 20   | 20   | 16   | 14    | 12    | 5     |
| 079           | 079             | 047              | 047                | 64   | 65   | 54   | 43    | 39    | 34    |
| 079           | 079             | 047              | 048                | 26   | 24   | 27   | 24    | 22    | 20    |
| 079           | 079             | 048              | 048                | 40   | 45   | 42   | 42    | 77    | 70    |
| 079           | 079             | 055              | 055                | 20   | 20   | 20   | 22    | 20    | 25    |
| 081           | 081             | 047              | 047                | 11   | 11   | 10   | 8     | 7     | 6     |
| 089           | 089             | 047              | 047                | 31   | 34   | 30   | 22    | 19    | 17    |
| 089           | 089             | 048              | 048                | 31   | 33   | 32   | 24    | 26    | 23    |
| 091           | 091             | 047              | 044                | 10   | 10   | 10   | 10    | 10    | 4     |
| 091           | 091             | 048              | 044                | 85   | 83   | 84   | 84    | 82    | 76    |
| 091           | 091             | 047              | 045                | 146  | 147  | 117  | 96    | 81    | 46    |

Table 35. (Continued)

| ORIGIN<br>BEA | SHIPPING<br>BEA | RECEIVING<br>BEA | DESTINATION<br>BEA | FOR COMMODITY GROUP 05 IN HUNDREDS OF TONS |       |       |       |       |       |
|---------------|-----------------|------------------|--------------------|--|-------|-------|-------|-------|-------|
|               |                 |                  |                    | 1976                                       | 1980  | 1990  | 2000  | 2020  | 2040  |
| 091           | 091             | 047              | 047                | 687  | 702   | 671   | 490   | 390   | 344   |
| 091           | 091             | 047              | 048                | 138  | 144   | 141   | 125   | 119   | 110   |
| 091           | 091             | 048              | 048                | 2734                                       | 2925  | 2786  | 2474  | 2357  | 2171  |
| 091           | 091             | 050              | 048                | 31   | 33    | 32    | 24    | 27    | 25    |
| 091           | 091             | 050              | 050                | 58   | 79    | 73    | 63    | 60    | 55    |
| 091           | 091             | 055              | 055                | 562  | 545   | 561   | 613   | 597   | 601   |
| 103           | 103             | 048              | 048                | 22   | 24    | 23    | 20    | 19    | 18    |
| 103           | 103             | 055              | 055                | 11   | 10    | 11    | 12    | 12    | 11    |
| 107           | 107             | 047              | 045                | 10   | 11    | 8     | 6     | 5     | 5     |
| 107           | 107             | 047              | 047                | 57   | 58    | 51    | 39    | 35    | 30    |
| 107           | 107             | 047              | 048                | 10   | 10    | 10    | 9     | 8     | 7     |
| 107           | 107             | 048              | 048                | 55   | 58    | 57    | 51    | 46    | 41    |
| 108           | 108             | 048              | 048                | 11   | 12    | 11    | 10    | 10    | 10    |
| 111           | 111             | 048              | 044                | 67   | 65    | 68    | 66    | 64    | 58    |
| 111           | 111             | 047              | 045                | 41   | 42    | 32    | 24    | 21    | 8     |
| 111           | 111             | 047              | 047                | 638  | 648   | 618   | 455   | 368   | 330   |
| 111           | 111             | 048              | 048                | 2193                                       | 2362  | 2239  | 1985  | 1890  | 1772  |
| 111           | 111             | 050              | 050                | 11   | 15    | 14    | 13    | 12    | 12    |
| 111           | 111             | 055              | 055                | 889  | 859   | 888   | 967   | 960   | 916   |
| 112           | 112             | 047              | 047                | 11   | 11    | 10    | 8     | 7     | 6     |
| 113           | 113             | 047              | 044                | 12   | 11    | 12    | 12    | 10    | 9     |
| 113           | 113             | 047              | 045                | 60   | 60    | 47    | 42    | 34    | 32    |
| 113           | 113             | 047              | 047                | 95   | 96    | 87    | 64    | 62    | 52    |
| 113           | 113             | 047              | 048                | 91   | 97    | 93    | 83    | 74    | 65    |
| 114           | 055             | 047              | 047                | 12   | 14    | 50    | 74    | 84    | 47    |
| 114           | 055             | 048              | 048                | 12   | 14    | 115   | 170   | 187   | 205   |
| 114           | 055             | 138              | 138                | 301  | 351   | 304   | 448   | 550   | 656   |
| 114           | 055             | 138              | 138                | 38   | 44    | 38    | 57    | 69    | 83    |
| 114           | 055             | 914              | 914                | 11   | 12    | 15    | 22    | 26    | 29    |
| 114           | 055             | 946              | 946                | 10   | 12    | 14    | 21    | 25    | 30    |
| 115           | 055             | 047              | 047                | 10   | 6     | 2     | 4     | 4     | 6     |
| 115           | 115             | 048              | 048                | 39   | 30    | 49    | 75    | 81    | 87    |
| 115           | 115             | 117              | 117                | 10   | 8     | 11    | 16    | 18    | 21    |
| 115           | 115             | 133              | 133                | 10   | 9     | 11    | 16    | 18    | 21    |
| 115           | 115             | 137              | 137                | 10   | 8     | 11    | 16    | 18    | 21    |
| 115           | 049             | 138              | 138                | 52   | 40    | 56    | 83    | 95    | 111   |
| 115           | 055             | 138              | 138                | 250  | 191   | 271   | 398   | 456   | 532   |
| 115           | 115             | 138              | 138                | 2078                                       | 1588  | 2253  | 3306  | 3786  | 4424  |
| 115           | 115             | 141              | 141                | 27   | 22    | 31    | 43    | 51    | 62    |
| 115           | 055             | 914              | 914                | 11   | 7     | 12    | 16    | 16    | 21    |
| 115           | 115             | 946              | 946                | 15   | 12    | 16    | 23    | 27    | 31    |
| 117           | 117             | 050              | 050                | 11   | 15    | 14    | 13    | 13    | 12    |
| 119           | 119             | 048              | 048                | 25   | 25    | 26    | 25    | 23    | 22    |
| 119           | 119             | 047              | 047                | 11   | 12    | 20    | 8     | 6     | 3     |
| 119           | 119             | 048              | 048                | 821  | 878   | 837   | 749   | 700   | 647   |
| 134           | 134             | 048              | 048                | 22   | 23    | 23    | 21    | 20    | 20    |
| 138           | 138             | 047              | 047                | 11   | 11    | 10    | 8     | 7     | 6     |
| 141           | 141             | 055              | 055                | 20   | 19    | 20    | 23    | 24    | 25    |
| 914           | 914             | 048              | 048                | 11   | 11    | 11    | 11    | 10    | 9     |
| 914           | 914             | 047              | 045                | 115  | 112   | 90    | 73    | 57    | 44    |
| 914           | 914             | 047              | 047                | 1002                                       | 1006  | 908   | 714   | 629   | 540   |
| 914           | 914             | 047              | 048                | 65   | 73    | 66    | 51    | 44    | 38    |
| 914           | 914             | 048              | 048                | 156  | 176   | 159   | 121   | 106   | 90    |
| 915           | 915             | 047              | 047                | 20   | 20    | 18    | 14    | 12    | 11    |
| 915           | 915             | 048              | 048                | 33   | 36    | 34    | 30    | 28    | 25    |
| 915           | 915             | 050              | 050                | 11   | 15    | 14    | 12    | 11    | 10    |
| TOTAL         |                 |                  |                    | 55820                                      | 41535 | 44964 | 60430 | 72750 | 86374 |

Note: BEAs 915, 914 and 946 refer to counties of BEAs 115, 114 and 46 which are origins and destinations of waterborne movements which are shipped from and to points on the Mississippi River. For PSA, the origin and destination BEAs are defined as points of production and consumption. Shipping and receiving BEAs refer only to that portion of the traffic flow which is waterborne (i.e., points of modal transfer).

Table 36. Ohio River System: Growth Rates of  
Grains Waterborne Commerce, BEA to BEA  
Projected 1976-2040, Selected Years

| BEA<br>Pair <sup>a</sup> | Group<br>No. | Index <sup>b</sup><br>Value | Year <sup>c</sup> |      |      |      |      |      |
|--------------------------|--------------|-----------------------------|-------------------|------|------|------|------|------|
|                          |              |                             | 1976              | 1980 | 1990 | 2000 | 2020 | 2040 |
| 046045                   | 05           | 10                          | 1000              | 700  | 900  | 1600 | 1700 | 2100 |
| 046047                   | 05           | 19                          | 1000              | 737  | 316  | 526  | 684  | 737  |
| 046048                   | 05           | 19                          | 1000              | 737  | 1158 | 2000 | 2158 | 2474 |
| 046111                   | 05           | 10                          | 1000              | 700  | 1100 | 1900 | 2100 | 2400 |
| 046137                   | 05           | 29                          | 1000              | 724  | 1138 | 1931 | 2276 | 2621 |
| 046138                   | 05           | 127                         | 1000              | 724  | 1260 | 2181 | 2606 | 3000 |
| 049038                   | 05           | 11                          | 1000              | 1091 | 1182 | 1545 | 2000 | 2545 |
| 049045                   | 05           | 11                          | 1000              | 818  | 1000 | 1455 | 1545 | 1909 |
| 049047                   | 05           | 23                          | 1000              | 870  | 346  | 435  | 565  | 652  |
| 049048                   | 05           | 48                          | 1000              | 938  | 1125 | 1563 | 1667 | 1875 |
| 049050                   | 05           | 20                          | 1000              | 1100 | 1300 | 1500 | 1650 | 1850 |
| 049055                   | 05           | 50                          | 1000              | 820  | 1120 | 1580 | 2360 | 2900 |
| 049111                   | 05           | 12                          | 1000              | 917  | 1167 | 1583 | 1917 | 2167 |
| 049137                   | 05           | 47                          | 1000              | 872  | 1106 | 1553 | 1723 | 1915 |
| 049138                   | 05           | 2471                        | 1000              | 906  | 1140 | 1570 | 1762 | 1961 |
| 052141                   | 05           | 11                          | 1000              | 727  | 909  | 1091 | 1273 | 1364 |
| 053137                   | 05           | 11                          | 1000              | 727  | 909  | 1182 | 1364 | 1545 |
| 053138                   | 05           | 325                         | 1000              | 708  | 883  | 1166 | 1342 | 1532 |
| 053946                   | 05           | 10                          | 1000              | 700  | 900  | 1200 | 1400 | 1600 |
| 054045                   | 05           | 24                          | 1000              | 833  | 875  | 1250 | 1500 | 1583 |
| 054047                   | 05           | 35                          | 1000              | 886  | 314  | 314  | 371  | 457  |
| 054048                   | 05           | 28                          | 1000              | 1000 | 1214 | 1571 | 1893 | 2321 |
| 054055                   | 05           | 13                          | 1000              | 769  | 1077 | 1692 | 3308 | 6308 |
| 054138                   | 05           | 1038                        | 1000              | 905  | 1139 | 1515 | 1951 | 2431 |
| 055038                   | 05           | 20                          | 1000              | 450  | 600  | 850  | 1150 | 1600 |
| 055044                   | 05           | 11                          | 1000              | 727  | 1182 | 1727 | 3273 | 5636 |
| 055045                   | 05           | 89                          | 1000              | 438  | 584  | 742  | 1034 | 1393 |
| 055047                   | 05           | 112                         | 1000              | 420  | 205  | 286  | 473  | 527  |
| 055048                   | 05           | 309                         | 1000              | 424  | 712  | 1000 | 1333 | 1680 |
| 055115                   | 05           | 20                          | 1000              | 950  | 1000 | 1050 | 1050 | 1100 |
| 055137                   | 05           | 416                         | 1000              | 442  | 623  | 875  | 1236 | 1642 |
| 055138                   | 05           | 17826                       | 1000              | 438  | 618  | 872  | 1224 | 1629 |
| 055140                   | 05           | 31                          | 1000              | 419  | 613  | 871  | 1226 | 1613 |
| 055141                   | 05           | 63                          | 1000              | 413  | 507  | 873  | 1190 | 1556 |
| 055143                   | 05           | 30                          | 1000              | 433  | 633  | 867  | 1233 | 1633 |
| 055914                   | 05           | 92                          | 1000              | 446  | 620  | 870  | 1228 | 1641 |
| 055946                   | 05           | 59                          | 1000              | 407  | 610  | 831  | 1169 | 1542 |
| 056047                   | 05           | 12                          | 1000              | 667  | 250  | 417  | 667  | 833  |
| 056048                   | 05           | 12                          | 1000              | 583  | 833  | 1167 | 1750 | 2417 |
| 056137                   | 05           | 20                          | 1000              | 600  | 850  | 1150 | 1700 | 2350 |
| 056138                   | 05           | 720                         | 1000              | 600  | 850  | 1179 | 1739 | 2367 |
| 057045                   | 05           | 14                          | 1000              | 929  | 786  | 714  | 571  | 571  |
| 057047                   | 05           | 55                          | 1000              | 1018 | 927  | 673  | 532  | 491  |

(Continued)

Table 36. (Continued)

| BEA<br>Pair <sup>a</sup> | Group<br>No. | Index<br>Value <sup>b</sup> | Year <sup>c</sup> |      |      |      |      |      |
|--------------------------|--------------|-----------------------------|-------------------|------|------|------|------|------|
|                          |              |                             | 1976              | 1980 | 1990 | 2000 | 2020 | 2040 |
| 057048                   | 05           | 49                          | 1000              | 1082 | 1000 | 918  | 857  | 755  |
| 060045                   | 05           | 11                          | 1000              | 727  | 818  | 1000 | 1364 | 1455 |
| 060047                   | 05           | 31                          | 1000              | 806  | 290  | 290  | 355  | 516  |
| 060048                   | 05           | 35                          | 1000              | 829  | 1029 | 1229 | 1714 | 2229 |
| 060055                   | 05           | 14                          | 1000              | 786  | 1071 | 1500 | 3071 | 4929 |
| 060137                   | 05           | 31                          | 1000              | 839  | 1000 | 1194 | 1774 | 2323 |
| 060138                   | 05           | 2291                        | 1000              | 807  | 986  | 1211 | 1753 | 2289 |
| 060914                   | 05           | 11                          | 1000              | 818  | 1000 | 1273 | 1909 | 2455 |
| 060946                   | 05           | 14                          | 1000              | 857  | 1000 | 1286 | 1786 | 2286 |
| 061048                   | 05           | 14                          | 1000              | 214  | 357  | 571  | 1000 | 1429 |
| 061137                   | 05           | 10                          | 1000              | 200  | 400  | 600  | 1000 | 1500 |
| 061138                   | 05           | 509                         | 1000              | 210  | 391  | 623  | 1057 | 1534 |
| 062038                   | 05           | 13                          | 1000              | 692  | 1077 | 1308 | 1462 | 1308 |
| 062045                   | 05           | 27                          | 1000              | 778  | 963  | 1296 | 1370 | 1444 |
| 062047                   | 05           | 42                          | 1000              | 881  | 357  | 405  | 429  | 452  |
| 062048                   | 05           | 76                          | 1000              | 921  | 1263 | 1487 | 1658 | 1829 |
| 062055                   | 05           | 35                          | 1000              | 800  | 1200 | 1457 | 2171 | 3429 |
| 062133                   | 05           | 12                          | 1000              | 750  | 1083 | 1333 | 1583 | 1750 |
| 062137                   | 05           | 145                         | 1000              | 855  | 1062 | 1297 | 1497 | 1710 |
| 062138                   | 05           | 8460                        | 1000              | 870  | 1082 | 1301 | 1516 | 1737 |
| 062914                   | 05           | 42                          | 1000              | 905  | 1071 | 1333 | 1571 | 1786 |
| 062946                   | 05           | 69                          | 1000              | 870  | 1087 | 1319 | 1536 | 1783 |
| 063047                   | 05           | 13                          | 1000              | 615  | 308  | 385  | 0    | 0    |
| 063048                   | 05           | 17                          | 1000              | 765  | 1471 | 2000 | 2412 | 2824 |
| 063055                   | 05           | 10                          | 1000              | 600  | 1100 | 1600 | 2800 | 3200 |
| 063137                   | 05           | 30                          | 1000              | 733  | 1333 | 1900 | 2200 | 2533 |
| 063138                   | 05           | 1744                        | 1000              | 739  | 1382 | 1916 | 2261 | 2607 |
| 063914                   | 05           | 11                          | 1000              | 727  | 1364 | 1909 | 2273 | 2545 |
| 063946                   | 05           | 14                          | 1000              | 786  | 1357 | 1929 | 2286 | 2643 |
| 064048                   | 05           | 15                          | 1000              | 667  | 933  | 1200 | 1400 | 1600 |
| 064055                   | 05           | 12                          | 1000              | 667  | 1083 | 1333 | 2167 | 2417 |
| 064137                   | 05           | 12                          | 1000              | 750  | 1083 | 1250 | 1417 | 1583 |
| 064138                   | 05           | 730                         | 1000              | 701  | 1000 | 1253 | 1405 | 1567 |
| 077044                   | 05           | 26                          | 1000              | 1000 | 1000 | 962  | 885  | 789  |
| 077045                   | 05           | 332                         | 1000              | 979  | 786  | 690  | 548  | 437  |
| 077047                   | 05           | 603                         | 1000              | 1013 | 914  | 713  | 668  | 539  |
| 077048                   | 05           | 514                         | 1000              | 1062 | 1021 | 875  | 778  | 761  |
| 078044                   | 05           | 16                          | 1000              | 938  | 1000 | 938  | 875  | 750  |
| 078045                   | 05           | 232                         | 1000              | 983  | 784  | 664  | 526  | 414  |
| 078047                   | 05           | 601                         | 1000              | 1010 | 913  | 712  | 652  | 521  |
| 078048                   | 05           | 363                         | 1000              | 1072 | 1017 | 873  | 774  | 771  |
| 078062                   | 05           | 11                          | 1000              | 1000 | 1000 | 1091 | 1182 | 1182 |
| 079045                   | 05           | 20                          | 1000              | 1000 | 800  | 700  | 600  | 250  |
| 079047                   | 05           | 64                          | 1000              | 1016 | 922  | 672  | 609  | 531  |
| 079048                   | 05           | 116                         | 1000              | 1060 | 1026 | 914  | 853  | 776  |
| 079055                   | 05           | 20                          | 1000              | 1000 | 1000 | 1100 | 1000 | 1250 |
| 081047                   | 05           | 11                          | 1000              | 1000 | 909  | 727  | 636  | 545  |
| 089047                   | 05           | 33                          | 1000              | 1030 | 909  | 667  | 576  | 515  |

(Continued)

Table 36. (Continued)

| BEA<br>Pair <sup>a</sup> | Group<br>No. | Index<br>Value <sup>b</sup> | Year <sup>c</sup> |      |      |       |       |       |
|--------------------------|--------------|-----------------------------|-------------------|------|------|-------|-------|-------|
|                          |              |                             | 1976              | 1980 | 1990 | 2000  | 2020  | 2040  |
| 089048                   | 05           | 31                          | 1000              | 1065 | 1032 | 935   | 839   | 742   |
| 091044                   | 05           | 95                          | 1000              | 979  | 980  | 939   | 968   | 895   |
| 091045                   | 05           | 146                         | 1000              | 1007 | 801  | 658   | 555   | 315   |
| 091047                   | 05           | 687                         | 1000              | 1022 | 977  | 713   | 568   | 501   |
| 091048                   | 05           | 2903                        | 1000              | 1070 | 1019 | 905   | 862   | 794   |
| 091050                   | 05           | 58                          | 1000              | 1362 | 1259 | 1086  | 1034  | 948   |
| 091055                   | 05           | 562                         | 1000              | 970  | 998  | 1091  | 1062  | 1069  |
| 103048                   | 05           | 22                          | 1000              | 1091 | 1045 | 909   | 864   | 818   |
| 103055                   | 05           | 11                          | 1000              | 909  | 1000 | 1091  | 1091  | 1000  |
| 107045                   | 05           | 10                          | 1000              | 1100 | 800  | 600   | 500   | 500   |
| 107047                   | 05           | 57                          | 1000              | 1018 | 895  | 684   | 614   | 526   |
| 107048                   | 05           | 65                          | 1000              | 1046 | 1031 | 923   | 831   | 738   |
| 108048                   | 05           | 11                          | 1000              | 1091 | 1000 | 909   | 909   | 909   |
| 111044                   | 05           | 67                          | 1000              | 970  | 1015 | 985   | 955   | 866   |
| 111045                   | 05           | 41                          | 1000              | 1024 | 780  | 585   | 512   | 195   |
| 111047                   | 05           | 638                         | 1000              | 1016 | 969  | 713   | 577   | 517   |
| 111048                   | 05           | 2193                        | 1000              | 1077 | 1021 | 905   | 862   | 808   |
| 111050                   | 05           | 11                          | 1000              | 1364 | 1273 | 1182  | 1091  | 1091  |
| 111055                   | 05           | 889                         | 1000              | 966  | 999  | 1088  | 1080  | 1030  |
| 112047                   | 05           | 11                          | 1000              | 1000 | 909  | 727   | 636   | 545   |
| 113044                   | 05           | 12                          | 1000              | 917  | 1000 | 1000  | 833   | 750   |
| 113045                   | 05           | 60                          | 1000              | 1000 | 783  | 700   | 567   | 533   |
| 113047                   | 05           | 95                          | 1000              | 1011 | 916  | 674   | 653   | 547   |
| 113048                   | 05           | 91                          | 1000              | 1066 | 1022 | 912   | 813   | 714   |
| 114047                   | 05           | 12                          | 1000              | 1167 | 4167 | 6167  | 7000  | 8083  |
| 114048                   | 05           | 12                          | 1000              | 1167 | 9583 | 14167 | 15583 | 17083 |
| 114138                   | 05           | 339                         | 1000              | 1165 | 1909 | 1490  | 1826  | 2180  |
| 114914                   | 05           | 11                          | 1000              | 1091 | 1364 | 2000  | 2364  | 2636  |
| 114946                   | 05           | 10                          | 1000              | 1200 | 1470 | 2100  | 2500  | 3000  |
| 115047                   | 05           | 10                          | 1000              | 600  | 200  | 400   | 400   | 600   |
| 115048                   | 05           | 39                          | 1000              | 769  | 1256 | 1923  | 2077  | 2231  |
| 115117                   | 05           | 10                          | 1000              | 800  | 1100 | 1600  | 1800  | 2100  |
| 115133                   | 05           | 10                          | 1000              | 900  | 1100 | 1600  | 1800  | 2100  |
| 115137                   | 05           | 10                          | 1000              | 800  | 1100 | 1600  | 1800  | 2100  |
| 115138                   | 05           | 2380                        | 1000              | 764  | 1084 | 1591  | 1822  | 2129  |
| 115141                   | 05           | 27                          | 1000              | 815  | 1148 | 1593  | 1889  | 2296  |
| 115914                   | 05           | 11                          | 1000              | 636  | 1091 | 1455  | 1455  | 1909  |
| 115946                   | 05           | 15                          | 1000              | 800  | 1067 | 1533  | 1800  | 2067  |
| 117050                   | 05           | 11                          | 1000              | 1364 | 1273 | 1182  | 1182  | 1091  |
| 119044                   | 05           | 25                          | 1000              | 1000 | 1040 | 1000  | 920   | 880   |
| 119047                   | 05           | 11                          | 1000              | 1091 | 1818 | 727   | 545   | 273   |
| 119048                   | 05           | 821                         | 1000              | 1069 | 1019 | 912   | 853   | 788   |
| 134048                   | 05           | 22                          | 1000              | 1045 | 1045 | 955   | 909   | 909   |
| 138047                   | 05           | 11                          | 1000              | 1000 | 909  | 727   | 636   | 545   |
| 141055                   | 05           | 20                          | 1000              | 950  | 1000 | 1150  | 1200  | 1250  |
| 914044                   | 05           | 11                          | 1000              | 1000 | 1000 | 1000  | 909   | 818   |
| 914045                   | 05           | 115                         | 1000              | 974  | 783  | 635   | 496   | 383   |
| 914047                   | 05           | 1002                        | 1000              | 1004 | 906  | 713   | 626   | 539   |

(Continued)



Table 36. (Continued)

| BEA<br>Pair <sup>a</sup> | Group<br>No. | Index<br>Value <sup>b</sup> | Year <sup>c</sup> |      |      |      |      |      |
|--------------------------|--------------|-----------------------------|-------------------|------|------|------|------|------|
|                          |              |                             | 1976              | 1980 | 1990 | 2000 | 2020 | 2040 |
| 914048                   | 05           | 221                         | 1000              | 1127 | 1018 | 778  | 679  | 579  |
| 915047                   | 05           | 20                          | 1000              | 1000 | 900  | 700  | 600  | 550  |
| 915048                   | 05           | 33                          | 1000              | 1091 | 1030 | 909  | 848  | 758  |
| 915050                   | 05           | 11                          | 1000              | 1364 | 1273 | 1091 | 1000 | 909  |

a. The first three digits indicate the BEA of origin; the last three digits indicate the BEA of destination.

b. Hundreds of tons.

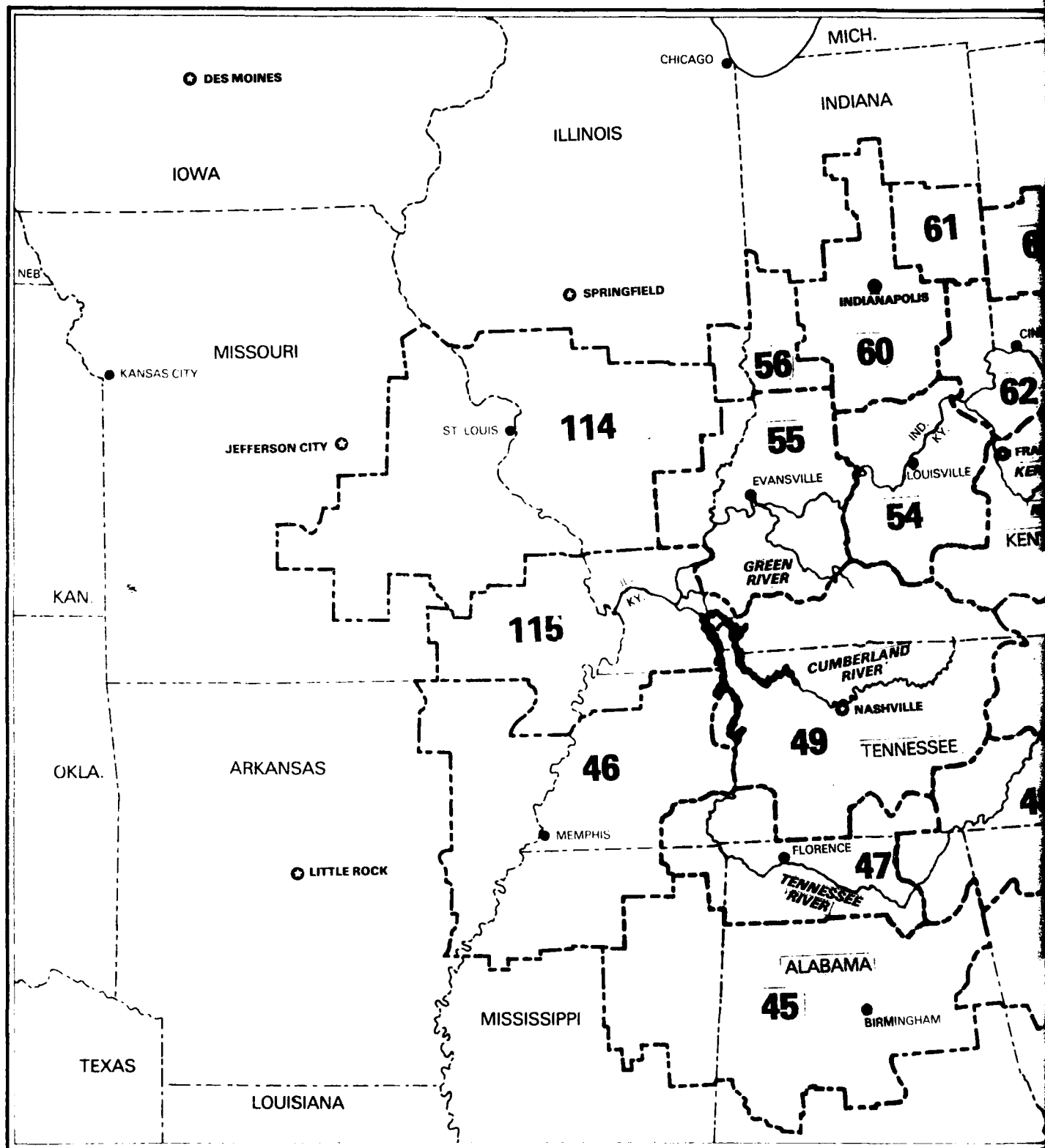
c. Growth rates are reported such that 1,000 equals the index value reported in the third column.

d. BEAs 915, 914, and 946 refer to counties of BEAs 15, 14, and 46 which are origins and destinations of waterborne movements which are shipped from and to points on the Mississippi River.

Source: Robert R. Nathan Associates, Inc.

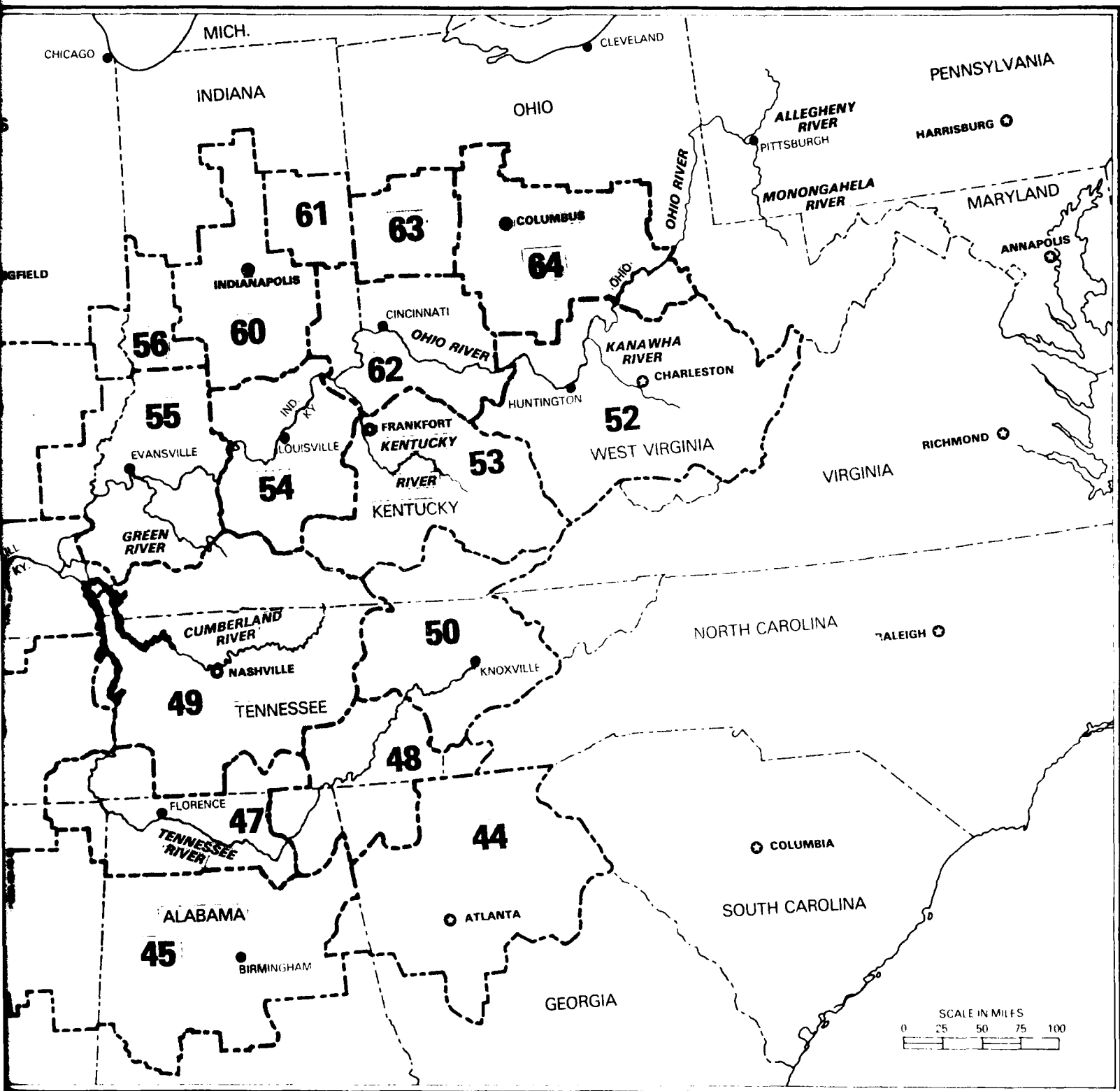
V. APPENDIX A

MAP. A-1. OHIO RIVER BASIN: PRIMARY STUDY AREAS  
(PEAS AND BEA SEGMENTS)



SOURCE: ROBERT P. NATHAN ASSOCIATES

MAP. A-1. OHIO RIVER BASIN: PRIMARY STUDY AREAS FOR GRAINS  
(PEAS AND BEA SEGMENTS)



Primary Study Areas

12

Table A-1. Ohio River Basin: Primary Study Areas for Grains  
(BEA and BEA segment)

BEA 44 (segment): Atlanta, GA

Cleburne, AL  
Barrow, GA  
Bartow, GA  
Cherokee, GA  
Clarke, GA  
Cobb, GA  
Dawson, GA  
DeKalb, GA  
Fannin, GA  
Floyd, GA  
Forsyth, GA  
Fulton, GA  
Gilmer, GA  
Gwinnett, GA  
Hall, GA  
Jackson, GA  
Lumpkin, GA  
Oconee, GA  
Pickens, GA  
Polk, GA  
Paulding, GA  
Towns, GA  
Union, GA  
Walton, GA  
White, GA

BEA 45 (segment): Birmingham, AL

Bibb, AL  
Blount, AL  
Calhoun, AL  
Cherokee, AL  
Chilton, AL  
Cullman, AL  
Etowah, AL  
Fayette, AL  
Jefferson, AL  
Lamar, AL  
Marion, AL  
Shelby, AL  
St. Clair, AL  
Walker, AL  
Winston, AL  
Itawamba, MS  
Lee, MS  
Pontotoc, MS  
Prentiss, MS  
Union, MS

BEA 46 (segment): Memphis, TN

Tippah, MS  
Carroll, TN  
Chester, TN  
Decatur, TN  
Henderson, TN  
Henry, TN  
Weakley, TN

BEA 47: Huntsville, AL

Colbert, AL  
Franklin, AL  
Lauderdale, AL  
Lawrence, AL  
Limestone, AL  
Madison, AL  
Marshall, AL  
Morgan, AL  
Alcorn, MS  
Tishomingo, MS  
Franklin, TN  
Hardin, TN  
Lincoln, TN  
McNairy, TN  
Wayne, TN

BEA 48 (segment): Chattanooga, TN

DeKalb, AL  
Jackson, AL  
Catoosa, GA  
Chattooga, GA  
Dade, GA  
Gordon, GA  
Murray, GA  
Walker, GA  
Whitfield, GA  
Bledsoe, TN  
Bradley, TN  
Grundy, TN  
Hamilton, TN  
McMinn, TN  
Marion, TN  
Meigs, TN  
Polk, TN  
Rhea, TN  
Sequatchie, TN

(Continued)

Table A-1 (continued).

BEA 49 (segment): Nashville, TN

Allen, KY  
Barren, KY  
Butler, KY  
Christian, KY  
Clinton, KY  
Cumberland, KY  
Edmonson, KY  
Logan, KY  
Metcalf, KY  
Monroe, KY  
Simpson, KY  
Todd, KY  
Trigg, KY  
Warren, KY  
Benton, TN  
Cannon, TN  
Cheatham, TN  
Clay, TN  
Coffee, TN  
Davidson, TN  
DeKalb, TN  
Dickson, TN  
Giles, TN  
Hickman, TN  
Houston, TN  
Humphreys, TN  
Jackson, TN  
Lawrence, TN  
Lewis, TN  
Macon, TN  
Maury, TN  
Montgomery, TN  
Overton, TN  
Perry, TN  
Pickett, TN  
Putnam, TN  
Robertson, TN  
Rutherford, TN  
Smith, TN  
Stewart, TN  
Sumner, TN  
Trousdale, TN  
Warren, TN  
White, TN  
Williamson, TN  
Wilson, TN  
Van Buren, TN

BEA 50 (segment): Knoxville, TN

Anderson, TN  
Blount, TN  
Campbell, TN  
Cumberland, TN  
Fentress, TN  
Grainger, TN  
Jefferson, TN  
Knox, TN  
Loudon, TN  
Monroe, TN  
Morgan, TN  
Roane, TN  
Scott, TN  
Sevier, TN  
Union, TN

BEA 52 (segment): Huntington, WV

Boyd, KY  
Carter, KY  
Elliott, KY  
Greenup, KY  
Lawrence, KY  
Rowan, KY  
Gallia, OH  
Lawrence, OH  
Meigs, OH  
Scioto, OH

BEA 53 (segment): Lexington, KY

Adair, KY  
Anderson, KY  
Bath, KY  
Bourbon, KY  
Boyle, KY  
Casey, KY  
Clark, KY  
Fayette, KY  
Franklin, KY  
Garrard, KY  
Green, KY  
Harrison, KY  
Jessamine, KY  
Lincoln, KY  
Mercer, KY  
Montgomery, KY  
Nicholas, KY  
Russell, KY  
Scott, KY  
Taylor, KY  
Woodford, KY

(Continued)

Table A-1 (continued).

BEA 54 (segment): Louisville, KY

Clark, IN  
Crawford, IN  
Floyd, IN  
Harrison, IN  
Jefferson, IN  
Orange, IN  
Scott, IN  
Washington, IN  
Breckinridge, KY  
Bullitt, KY  
Grayson, KY  
Hardin, KY  
Hart, KY  
Henry, KY  
Jefferson, KY  
Larue, KY  
Marion, KY  
Meade, KY  
Nelson, KY  
Oldham, KY  
Shelby, KY  
Spencer, KY  
Trimble, KY  
Washington, KY

BEA 55 (segment): Evansville, IN

Edwards, IL  
Gallatin, IL  
Hamilton, IL  
Saline, IL  
Wabash, IL  
White, IL  
Daviess, IN  
Dubois, IN  
Gibson, IN  
Knox, IN  
Martin, IN  
Perry, IN  
Pike, IN  
Posey, IN  
Spencer, IN  
Vanderburgh, IN  
Warrick, IN  
Caldwell, KY  
Crittenden, KY  
Daviess, KY  
Hancock, KY  
Henderson, KY  
Hopkins, KY  
McLean, KY  
Muhlenberg, KY  
Ohio, KY  
Union, KY  
Webster, KY

BEA 56 (segment): Terre Haute, IN

Green, IN  
Sullivan, IN

BEA 60 (segment): Indianapolis, IN

Bartholomew, IN  
Boone, IN  
Brown, IN  
Decatur, IN  
Hamilton, IN  
Hancock, IN  
Hendricks, IN  
Jackson, IN  
Jennings, IN  
Johnson, IN  
Lawrence, IN  
Marion, IN  
Monroe, IN  
Morgan, IN  
Rush, IN  
Shelby, IN

BEA 61 (segment): Anderson, IN

Henry, IN  
Wayne, IN

BEA 62: Cincinnati, OH

Dearborn, IN  
Fayette, IN  
Franklin, IN  
Ohio, IN  
Ripley, IN  
Switzerland, IN  
Union, IN  
Boone, KY  
Bracken, KY  
Campbell, KY  
Carroll, KY  
Fleming, KY  
Gallatin, KY  
Grant, KY  
Kenton, KY  
Lewis, KY  
Mason, KY  
Owen, KY  
Pendleton, KY  
Robertson, KY  
Adams, OH  
Brown, OH  
Butler, OH  
Clermont, OH  
Clinton, OH  
Hamilton, OH  
Highland, OH  
Warren, OH

(Continued)

Table A-1 (continued).

BEA 63: Dayton, OH  
Champaign, OH  
Clark, OH  
Darke, OH  
Greene, OH  
Logan, OH  
Miami, OH  
Montgomery, OH  
Preble, OH  
Shelby, OH

BEA 64 (segment): Columbus, OH  
Athens, OH  
Delaware, OH  
Fayette, OH  
Franklin, OH  
Guernsey, OH  
Hocking, OH  
Jackson, OH  
Madison, OH  
Morgan, OH  
Noble, OH  
Pickaway, OH  
Pike, OH  
Ross, OH  
Union, OH  
Vinton, OH  
Washington, OH

BEA 114 (segment): St. Louis, MO  
Franklin, IL  
Jefferson, IL  
Wayne, IL

BEA 115 (segment): Paducah, KY  
Alexander, IL  
Hardin, IL  
Massac, IL  
Pope, IL  
Pulaski, IL  
Ballard, KY  
Calloway, KY  
Carlisle, KY  
Graves, KY  
Hickman, KY  
Livingston, KY  
Lyon, KY  
McCracken, KY  
Marshall, KY

---

Source: Robert R. Nathan Associates, Inc.



## VI. APPENDIX B

### LAND CAPABILITY CLASSIFICATION

The following land capability classification system, as developed by the U.S. Department of Agriculture (USDA), Soil Conservation Service, was used as the basis for estimating the potential cropland resource base for future grain production in the PSAs.

The capability classification provides three major categories: (1) unit (the smallest subdivision), (2) subclass, and (3) class (broadest).

The land capability unit is a grouping of soils that are adapted to the same kinds of cultivated crops and pasture plants and that require similar systems of management for these crops.

The land capability subclass is a grouping of land capability units having similar kinds of limitations or hazards. Four kinds of limitations or hazards are recognized: (1) erosion, (2) wetness, (3) soil limitations in the root zone, and (4) adverse climate.

The third and broadest category in the capability classification places all the soils in eight land capability classes. The risks of soil damage or the limitations in use are progressively greater from class I to class VIII. Soils in the first four classes are capable, with good management, of producing adapted cultivated field crops, pasture plants, forest trees, or other adapted plants. Soils in classes V, VI, and VII are suited to the use of adapted native plants. Some soils in classes V and VI are also capable of producing specialized crops, such as certain fruit and ornamentals, and field and vegetable crops under highly intensive management involving elaborate practices for soil and water conservation. Soils in class VIII do not return on-site benefits for inputs of management for crops, grasses, or trees.

This classification system was adopted by each of the eight ORS hinterland states in their inventories of land in 1967 and provides a comparative and consistent set of data upon which to estimate potential cropland. Generalized definitions follow of the land capability classes as used in the Inventory of Soil and Water Conservation Needs for the States of Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio, and Tennessee.

The following five classes and subclasses of land were considered by the USDA Soil Conservation Service to be a conservative estimate of that land in any one county that was suitable as cropland: I, IIe, IIw, IIIe, and IIIw.

Land Suited for Cultivation and Other Uses

Class I. Soils in class I have few limitations that restrict their use.

Soils in this class are suited to a wide range of plants and may be used safely for cultivated crops, pasture, woodland, and wildlife. The soils are nearly level, and erosion hazard is low. They are deep, generally well drained, and easily worked. They hold water well and are either fairly well supplied with plant nutrients or highly responsive to inputs of fertilizer.

The soils in class I are not subjected to damaging overflow. They are productive and suited for intensive cropping. The local climate must be favorable for growing many of the common field crops.

Soils that are wet and have slow or very slow permeable subsoils are not placed in class I. Some kinds of soil in class I may be drained as an improvement measure for increased production and ease of operation.

Soils in class I that are used for crops need ordinary management practices to maintain productivity--both soil fertility and soil structure. Such practices may include the use of one or more of the following: fertilizers and lime, cover and green manure crops, conservation of crop residues and animal manures, and sequences of adapted crops.

Class II. Soils in class II have some limitations that reduce the choice of plants or require moderate conservation practices.

Soils in this class require careful soil management, including conservation practices, to prevent deterioration or to improve air and water relations when the soils are cultivated. The limitations are few, and the practices are easy to apply. The soils may be used for cultivated crops, pasture, and woodland or for wildlife food and cover.

Limitations of soils in class II may include singly or in combination the effects of (1) gentle slopes, (2) moderate susceptibility to water erosion or moderate adverse effects of past erosion, (3) less than ideal soil depth, (4) somewhat unfavorable soil structure and workability, (5) occasional damaging overflow, and (6) wetness correctable by drainage but existing permanently as a moderate limitation.

The soils in this class provide the farm operator less latitude in the choice of either crops or management practices than soils in class I. They may also require special soil-conserving cropping systems, soil conservation practices, water control devices, or tillage methods when used for cultivated crops. For example, deep soils of this class with gentle slopes that are subject to moderate erosion when cultivated may need one of the following practices or some combination of two or more: terracing, strip cropping, contour tillage, crop rotations that include grasses and legumes, vegetated water disposal areas, cover and green manure crops, stubble mulching, fertilizers, manure, and lime. The exact combinations of practices vary from place to place, depending on the characteristics of the soil, the local climate, and the farming system.

Class III. Soils in class III have severe limitations that reduce the choice of plants or require special conservation practices or both.

Soils in class III have more restrictions than those in class II, and when used for cultivated crops, the conservation practices are usually more difficult to apply and maintain. These soils may be used for cultivated crops, pasture, and woodland or for wildlife food and cover.

Limitations of soils in class III restrict the amount of clean cultivation, timing of planting, tillage and harvesting, choice of crops, or a combination of these items. Limitations may result from the effects of one or more of the following: (1) moderately steep slopes; (2) high susceptibility to water erosion or severe adverse effects of past erosion; (3) frequent overflow accompanied by some crop damage; (4) very slow permeability of the subsoil; (5) wetness of some continuing waterlogging after drainage; (6) shallow depths to bedrock hardpan, fragipan, or claypan that limits the rooting zone and the water storage; (7) low moisture-holding capacity; and (8) low fertility not easily corrected.

When cultivated, many of the wet, slowly permeable but nearly level soils in class III require a drainage system and a cropping system that maintains or improves the structure and tilth of the soil. To prevent puddling and to improve permeability, it is commonly necessary to supply organic material to such soils and to avoid working them when they are wet. Each distinctive kind of soil in class III has one or more alternative combinations of use and practices required for safe use, but the number of practical alternatives for average farmers is less than for soils in class II.

#### Capability Subclass

Subclass is a group of capability units within classes that have the same kind of dominant limitations for agricultural use. Some soils are subject to erosion if they are not protected, while others are naturally wet and must be drained if crops are to be grown. Some soils are shallow or droughty or have other deficiencies. Still other soils occur in areas where climate limits their use. The three kinds of recognized limitations at the subclass level are: risks of erosion, designated by the symbol "e"; wetness, drainage or overflow, designated by the symbol "w"; and rootzone limitations, designated by the symbol "s". Subclasses are not recognized in capability class I.

Subclass "e" is made up of soils where the susceptibility to erosion is the dominant problem or hazard in their use. Erosion susceptibility and past erosion damage are the major soil factors for placing soils in this subclass.

Subclass "w" is made up of soils where excess water is the dominant hazard or limitation to their use. Poor soil drainage, wetness, high water table, and overflow are the criteria for determining which soils belong in this subclass.

For the purposes of this study, classes IV-VIII and subclass "s" soils were considered to be limited in use and generally not suited for cultivation.

## VII. SOURCES AND REFERENCES

### A. Reports and Publications

Alabama State Conservation Needs Inventory Committee.  
Alabama Conservation Needs Inventory. 1967 ed.  
Auburn, AL: USDA, 1970.

Alabama Crop and Livestock Reporting Service. Agricultural  
Statistics. 1969-76 eds. Montgomery, AL: Alabama  
Crop and Livestock Reporting Service.

Brooks, B.L. and L.D. Hill. Production of Feed Grains  
and Use by Livestock in Illinois, 1957-1973 and  
Projected to 1980 and 1985. AE-4404. A Statistical  
Appendix to AERR-143. Urbana-Champaign, IL:  
University of Illinois. Department of Agricultural  
Economics, 1976.

Browning, W., H.H. Hall, and D.M. Shuffett. Production and  
Feed Grain Utilization Balances in Kentucky by Substate  
Areas (1953-1970 and Projection to 1980). Agricultural  
Economics Extension Information Series No. 10.  
Lexington, KY: University of Kentucky, 1972.

Browning, W., H.H. Hall, and D.M. Shuffett. Trends and  
Projections in Kentucky's Livestock Industry (By  
Substate Areas). Agricultural Economics Extension  
Information Series No. 13. Lexington, KY: University  
of Kentucky, 1973.

Distilled Spirits Council of the U.S. Annual Statistical  
Review. 1977 ed. Washington, D.C.: DISCUS, 1978.

Free, W.J., L.E. Stone, and D. Baldwin. Transportation Rates for Corn, Wheat and Soybeans. Southern Cooperative Regional Series No. 227. Bulletin Y-124. Muscle Shoals, AL: National Fertilizer Development Center, 1978.

Georgia Soil and Water Conservation Needs Inventory Committee. Conservation Needs Inventory. 1967 ed. Athens, GA: USDA, 1970.

Georgia Crop Reporting Service. Corn: County Estimates. May 22, 1978 release. Athens, GA: Georgia CRS, 1978.

Georgia Crop Reporting Service. Soybeans: County Estimates. June 23, 1978 release. Athens, GA: Georgia CRS, 1978.

Georgia Crop Reporting Service. Wheat: County Estimates. April 7, 1978 release. Athens, GA: Georgia CRS, 1978.

Hill, L.D. and B.L. Brooks, The Market for Illinois Grains. Urbana-Champaign, IL: University of Illinois. Department of Agricultural Economics, 1976.

Illinois Conservation Needs Committee. Soil and Water Conservation Needs Inventory. 1967 ed. Urbana-Champaign: University of Illinois. College of Agriculture, 1970

Illinois Cooperative Crop Reporting Service. Corn and Soybean Estimates, by Counties. 1969-76 ed. Springfield, IL: USDA, n.d.

Illinois Cooperative Crop Reporting Service. Wheat and Oat Estimates, by Counties. 1969-76 eds. Springfield, IL: USDA, n.d.

Illinois Cooperative Crop Reporting Service. Illinois Agricultural Statistics. 1969-77 eds. Springfield, IL: USDA, 1970-78.

Indiana State Conservation Needs Committee. Soil and Water Conservation Needs Inventory. 1967 ed. Indianapolis: Soil Conservation Service, 1968.

- Indiana Crop and Livestock Reporting Service. Field Crops. 1969-76 eds. Lafayette, IN: USDA.
- Indiana Crop and Livestock Statistics. Historic Crop and Livestock Summary. 1969-76. Lafayette, IN: USDA.
- Jones, B.F., J.W. Sharp, and D. Baldwin. Structure of the Grain Market in Surplus Feed Grain Areas. Southern Cooperative Services No. 207. Research Bulletin No. 927. West Lafayette, IN: Purdue University, 1975.
- Kentucky State Conservation Needs Inventory Committee. Soil and Water Conservation Needs Inventory. 1967 ed.
- Kentucky Crop and Livestock Reporting Service. Agricultural Statistics. Various releases. Louisville, KY: USDA.
- Kentucky Crop and Livestock Reporting Service. Corn: County Estimates. Various releases. Louisville, KY: USDA.
- Kentucky Crop and Livestock Reporting Service. Livestock and Poultry. Various releases. Louisville, KY: USDA.
- Kentucky Crop and Livestock Reporting Service. Soybean: County Estimates. Various releases. Louisville, KY: USDA.
- Kentucky Crop and Livestock Reporting Service. Wheat: County Estimates. Various releases. Louisville, KY: USDA.
- Mississippi Crop and Livestock Reporting Service. Mississippi Agricultural Statistics. 1954-73 and 1974-76 eds. Jackson, MS: USDA, n.d. and 1977.
- National Grain and Feed Association. Directory of River Barge Shipping Points. May 1978 ed. Washington, D.C.: NGFA, 1978.
- Ohio Agricultural Research and Development Center. Grain Facilities in the U.S. Specializing in Originating Grain for Export and Soybean Processing Plants. Research Circular 241. By John Sharp. Wooster, OH: OARDC, 1978.
- Ohio Agricultural Research and Development Center. Grain Production Projections in Ohio by Crop Reporting District and County in 1964, 1989, and 1999. Research Bulletin 1101. By D.W. Larson, H.C. Bedestenci and E. Canles. Wooster, OH: OARDC, 1978.

- Ohio Agricultural Research and Development Center. Grain Market Structure, Flows, and Functions of Elevator and Processing Firms. Research Bulletin 1087. By E.D. Baldwin and J.W. Sharp. Wooster, OH: OARDC, 1976.
- Ohio Agricultural Research and Development Center. Land Use in Ohio, 1900-1970: How and Why it has Changed. Research Bulletin 1084. By J.H. Sitterley. Wooster, OH: OARDC, 1976.
- Ohio Agricultural Research and Development Center. The Mid-western and Southern U.S. Grain Merchandising Patterns: A Contrast. Research Bulletin 1092. By E.D. Baldwin and W.L. Bateman. Wooster, OH: OARDC, 1977.
- Ohio Agricultural Research and Development Center. Ohio and the Food System: A Base for Planning. Research Circular 234. By D.R. Henderson and W. Barr. Wooster, OH: OARDC, 1977.
- Ohio Agricultural Research and Development Center. Western Ohio Grain Flows and Transportation Modes, 1975-76. Research Circular. By D.W. Larson and M.D. Kane. Wooster, OH: OARDC, 1978.
- Ohio Grain, Feed and Fertilizer Association. Directory of Grain, Feed, Fertilizer and Milling Operations of Ohio. 1978 ed. Worthington, OH: OGFFA, n.d.
- Ohio Soil and Water Conservation Needs Committee. Soil and Water Conservation Needs Inventory. 1967 ed. Columbus, OH: USDA, 1971.
- Ohio Crop Reporting Service. Agricultural Statistics. 1969-77 ed. Columbus, OH: USDA, 1970-78.
- Sappington, C.B., L.D. Hill, and E.D. Baldwin. Spatial Price Differentials for Corn. Southern Cooperative Series Bulletin 196. Knoxville, TN: Tennessee Agricultural Experiment Station, 1975.
- Shuffett, D.M. Developments in Kentucky Agriculture and Projections of Some Major Aspects of Kentucky Agriculture to 1980. Agricultural Economics Extension Information Series No. 8. Lexington, KY: University of Kentucky, 1972.



- Stallings, J.L., J.M. Harris, and C. Sappington. Grain Movements Between Southern and Corn Belt States: A Special Relationship. Southern Cooperative Series Bulletin No. 209. Auburn, AL: Alabama Agricultural Experiment Station, 1976.
- Tennessee Conservation Needs Inventory Committee. Tennessee Soil and Water Conservation Needs Inventory. 1967 ed. Nashville, TN: USDA, 1971.
- Tennessee Crop Reporting Service. Tennessee Agricultural Statistics. 1978 eds. Nashville, TN: USDA, 1978 ed.
- Tennessee Crop Reporting Service. Corn: County Estimates. Various releases. Nashville, TN: USDA.
- Tennessee Crop Reporting Service. Soybeans: County Estimates. Various releases. Nashville, TN: USDA.
- Tennessee Crop Reporting Service. Wheat: County Estimates. Various releases. Nashville, TN: USDA.
- University of Kentucky. College of Agriculture. Production Potential Study Committee. Agricultural Potentials for Kentucky. Lexington, KY: University of Kentucky, 1977.
- U.S. Army Corps of Engineers. Interstate Commerce Commission Railroad Waybill Sample. 1969, 1972 and 1976. Data provided on computer tape.
- U.S. Army Corps of Engineers. Waterborne Commerce by Port Equivalents. 1969-76. Data provided on computer tape.
- U.S. Department of Agriculture. Agricultural Statistic. (Various Years). Washington, D.C.: USDA.
- U.S. Department of Agriculture. Crop Reporting Board. Crop Production; Annual Summary: Acreage, Yield and Production (Various issues). Washington, D.C.: USDA.
- U.S. Department of Agriculture. Crop Reporting Board. Crop Values. 1975-1976-1977 eds. Washington, D.C.: USDA, 1978.

U.S. Department of Agriculture. Economic Research Service. Agriculture, the Third Century: Commodity Production and Utilization Projections to 1985. Number 2. Compiled by Allen G. Smith. Washington, D.C.: USDA, 1976.

U.S. Department of Agriculture. Economic Research Service. Livestock-Feed Relationships: National and State. Statistical Bulletin No. 530. Washington, D.C.: USDA, 1974.

U.S. Department of Agriculture. Economic Research Service. Livestock-Feed Relationships: National and State. Supplement for 1974 to Statistical Bulletin No. 530. Washington, D.C.: USDA, 1975.

U.S. Department of Agriculture. Economic Research Service. Water Carriers and Inland Waterways in Agricultural Transportation. Agricultural Economic Report No. 379. By Floyd D. Gaibler. Washington, D.C.: USDA, 1977.

U.S. Department of Agriculture. Economics, Statistics and Cooperatives Service. Feed Situation. Various issues. Washington, D.C.: USDA.

U.S. Department of Commerce. Bureau of the Census. Census of Agriculture. Alabama, Georgia, Illinois, Indiana, Kentucky, Mississippi, Ohio and Tennessee Volumes. 1974 ed. Washington, D.C.: GPO, 1977.

U.S. Department of Transportation. Distribution Systems Analysis. Vol. II of Modal Traffic Impacts of Waterway User Charges. Washington, D.C.: GPO, 1977.

B. Associations, Government Agencies  
Educational Institutions

Alabama Crop Reporting Service

Cincinnati Board of Trade

Georgia Crop Reporting Service

Illinois Crop Reporting Service

Indiana Crop Reporting Service  
Kentucky Crop Reporting Service  
Kentucky Department of Commerce  
Kentucky River Development Authority  
Louisville Board of Trade Grain  
Mississippi Crop Reporting Service  
Ohio Crop Reporting Service  
Ohio River Basin Commission  
Ohio State University, Department of  
Agricultural Economics  
Purdue University, Department of  
Agricultural Economics  
Tennessee Crop Reporting Service  
U.S. Department of Agriculture, Crop  
Reporting Service  
U.S. Department of Agriculture, Economic  
Research Service  
University of Kentucky, College of Agri-  
cultural  
University of Tennessee, Department of  
Agricultural Economics

C. Industrial Shippers and Receivers

ADM Milling, Mt. Vernon, Indiana

Alabama Farmers Co-op, Decatur, Alabama

Allied Mills, Guntersville, Alabama

American Commercial Barge Line  
Company, Jeffersonville, Indiana

American Maize Products, Decatur, Alabama

Aurora Terminal, Aurora, Indiana

Bunge, Cairo, Illinois

Cargill, Chattanooga, Tennessee

Central Soya Company, Chattanooga, Tennessee

Central Soya Company, Cincinnati, Ohio

Central Soya Company, Henderson, Kentucky

Clifton Mills, Clifton, Ohio

Con Agra

Continental Grain, Guntersville, Alabama

Continental Grain, Mt. Vernon, Indiana

Davis Grain and Milling, Owensboro, Kentucky

Dixie Portland Flour Mill, Chattanooga, Tennessee

Early and Daniel, Cincinnati, Ohio

Early and Daniel, Louisville, Kentucky

Gold Kist, Atlanta, Georgia

Gold Kist, Decatur, Alabama

Indiana Grain Goldproff, Louisville, Kentucky

Indiana Grain/Queen City Elevators, Cincinnati, Ohio

Owensboro Grain Terminal, Owensboro, Kentucky

Paducah-McCracken Port Authority, Paducah, Kentucky

Piqua Milling, Piqua, Ohio

Pillsbury Company, Cincinnati, Ohio

Ralston Purina, Louisville, Kentucky

Rigsby and Barnard McClansboro, Illinois

Seaboard Allied Milling Company, Chattanooga, Tennessee

DATE  
FILMED  
— 8